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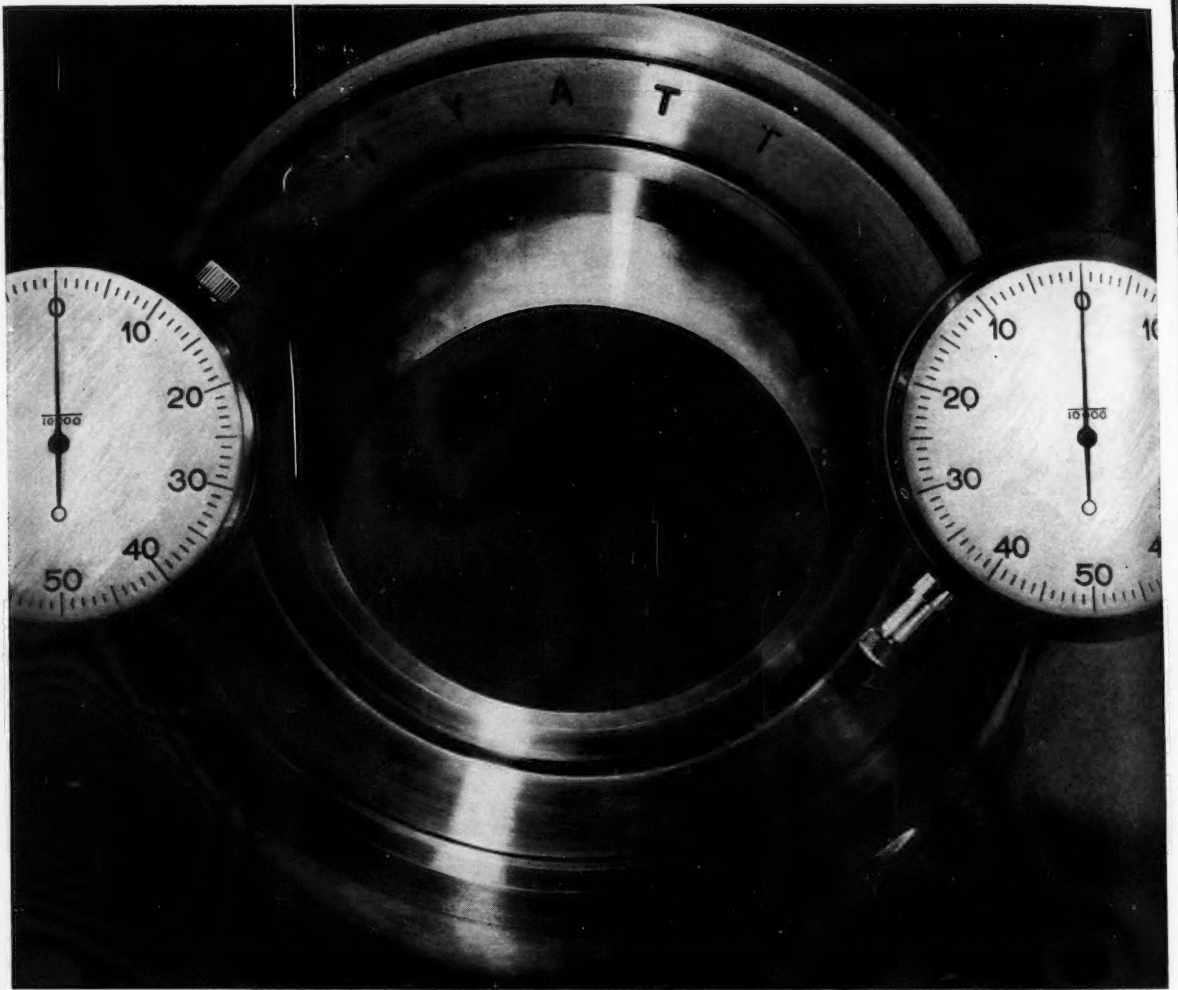
Number 8

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# AGRICULTURAL ENGINEERING

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## Ditch Cleaning Experiments in Delaware<sup>1</sup>

By W. D. Ellison<sup>2</sup>

SINCE THE INTRODUCTION of the dredge about 1885, many large systems of ditches and canals for drainage and irrigation have been built in the United States. The maintenance of these channels in efficient operating condition after construction is essential, if they are to continue to contribute to development and use of the land they serve. The demands of new construction work, however, seem to have mainly absorbed the attention of engineers and manufacturers of ditching machinery, and not much thought has been given to methods and equipment for maintenance work. Little has been done toward developing or adapting machinery to the special needs of repairing open channels and keeping them in operating condition, or in accumulating data on methods and costs of doing such work.

The purpose of this paper is to give a brief outline of ditch maintenance work being done in Delaware, to give costs of this and other channel-cleaning work, and to briefly discuss machines now available for maintenance. Cost data on maintenance there should have wide application, because there are many thousands of miles of open channels once dredged and now considerably ineffective by reason of inadequate maintenance or no maintenance at all.

The legislature of Delaware in its last session appropriated \$10,000 annually for two years to be used to improve and maintain drainage channels in Kent County. On September 28, 1931, the state highway department and the U.S.D.A. Bureau of Agricultural Engineering signed an agreement providing that the two services should cooperate in carrying out the drainage work provided for by the state legislature.

<sup>1</sup>A paper presented at a joint session of the Power and Machinery Division and the Land Reclamation Division of the American Society of Agricultural Engineers at their 26th annual meeting at Columbus, Ohio, June 1932.

<sup>2</sup>Assistant drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Assoc. Mem. A.S.A.E.

In the past, landowners on individual watersheds in Delaware were organized for the purpose of collecting a ditch maintenance tax. Maintenance work was hand labor, supervised by overseers appointed by the organization from their own membership. An overseer would usually supervise a section about one mile long. During the last ten years an average of \$100 to \$150 per mile has been spent annually on some of the channels, but this has not provided adequate maintenance. The almost complete failure of all channels in this section of the state is a striking example of what may be expected on many projects if proper engineering supervision is not applied.

The program adopted and now being carried out by the state highway department and the federal bureau of agricultural engineering provides for a series of experiments to determine the costs of cleaning the ditches by different methods. Hand labor, teams and scoops, tractors and scoops, dynamite, and dredges are all being used, and accurate determinations of costs are made for each job. After the channels are once properly repaired, a system of ditch patrol is to be established. A small fund has been reserved for chemical treatment to kill vegetation growing within and along the ditches.

Fig. 1 shows three typical channels in Kent County, Delaware. In this section trees, wild raspberries, wild blackberries, and green briars grow profusely along the channels. During the growing season these growths obstruct the ditches and greatly reduce their capacities. Cleaning this vegetation away with hand labor is a slow and costly job, which must be done every year. It is possible that chemical treatment will prove less costly and greatly improve drainage conditions during the growing seasons.

**Hand Labor.** To determine the cost of hand labor in cleaning channels, a crew of eleven men, with a foreman experienced in handling ditch work, was employed for about four weeks. Men with shovels were paid 30 c per hour, and the foreman 40 c. This crew worked on three different



Fig. 1. Trees and briars quickly obstruct ditches in Kent County, Delaware, and have necessitated annual cleaning by hand labor. This has proven expensive and not entirely effective





Fig. 2. (Left) Tractor with double winch, (center) loading of scoop, and (right) snatchblock arrangement at anchor end of haulback cable for cleaning ditches with scoop and tractor

sizes of channels. In a ditch having a top width of about 25 ft, bottom width of 10 ft, and depth of 5 ft, the cost of removing silt was 83 c per cu yd of material taken out. On ditches having top widths of 6 to 10 ft, bottom widths of 1½ to 4 ft, and depths of about 4 ft, the cost of removing silt was 40 c per cu yd.

**Horses and Scoops.** Although hand labor has been about the only method employed for cleaning ditches of all sizes in this county, some teams and scrapers have been used. For this work, inclines are cut in the side slopes every 300 ft along the ditch. Teams enter at one incline, load the scrapers in the ditch, and pull out at the next incline up stream. Usually 3 to 5 teams work in a 300-ft section. Small slip scrapers of 4 to 5 cu ft capacity are used. To determine costs of this work, accurate cross-sections were made at short intervals through 1500 ft of channel. The ditch had a top width of 20 to 25 ft, bottom width of 10 ft, and depth of 5 ft. Men with teams that had previously been employed on this work were hired. A man with a team was paid 55 c per hr. Scoop stickers were paid 25 c per hr and the foreman 40 c per hr. Five teams worked the greater part of the time. Two scoop stickers worked in the ditch and an experienced foreman supervised. This method of removing silt cost 62 c per cu yd. Soil and channel conditions were almost identical with those where hand labor had cost 83 c per cu yd.

#### A LOW INVESTMENT OUTFIT

**Tractor and Scoops.** A double-drum winch was installed on a 35-hp tractor to drag slip scoops through the ditch. (See Fig. 2.) A haul back was arranged so that when one scoop was pulled from the channel another was pulled back into the ditch. For anchoring the haul back line, three 4x6-in fir posts were set 40 in in the ground and 96 ft apart on a line parallel to the ditch. Two pieces of ½-in cable, each 96 ft long, were arranged with a loop at each end to drop over these posts. A ¾-in thimble was fastened into the cable every 12 ft, for hooking snatch blocks. Each thimble was fastened with one cable clip. For the drag cables on the winches ¾-in cable was used, and a hook was fastened to the end of each drag cable. A ¾-in haul back cable with a thimble in each end was fastened to these hooks, and taken back through the two 8-in snatch blocks which were set 12 to 24 ft apart on the anchor cable. To move along the ditch, the snatch blocks are unhooked and set further along the anchored cable.

The success of this method is quite dependent on obtaining proper scoops. Scoops must have large teeth so that they will load in hard clay and gravel. They must have long handles to make loading and dumping easier. They must be wide to make a good job of trimming. The distance from the back of the scoop to the hitch must be short so that the cutting edge can be held up to prevent cutting on steep banks.

We are still experimenting with scoops. Many improve-

ments have been made since the work started, and further improvements are contemplated. The scoops are fastened to the drag cables with an 11-ft lead cable. This permits the men to work up and down the ditch from the haul backs and gives them time to place the scoop without stopping the tractor. The average speed of the winch is about 125 fpm. By using the short lead cable, the men in the ditch have about 11 sec to place a scoop. Usually the snatch blocks are set 24 ft apart, and the average section of ditch cleaned per set up is about 30 ft long. Four men on the scoops and the tractor operator comprise the crew. Two men stay in the ditch for loading, and two stay on the bank for dumping. The tractor operator acts as foreman, and one of the men on the bank assists him by signaling when it is necessary to stop. The two men in the ditch move the snatch blocks forward and keep the anchor posts set, while the two men on the bank assist the tractor operator to move his machine and the cables and to properly align the tractor with the haul backs. A small tool box and magazine were mounted on skids and hauled along with the tractor.

Accurate cross-sectioning of this work showed that under most unfavorable conditions, the side slopes being covered with stumps and very irregular, excavation costs were about 26 c per cu yd. In excavating quantities of about 15 cu yd per 100 ft, about 600 ft per day can be cleaned by this method.

One advantage of this outfit in our work has been that it required very little initial investment. The state highway department owns the tractor and will use it in road work when the ditching is discontinued. Other advantages are that very little clearing outside the channel is required, for the cables and scoops can be operated between the

The life of open ditches is short in most soils unless they are kept reasonably free of sediment, debris and vegetation. The experiments in ditch maintenance work in Delaware have shown that such work performed by hand labor has been costing the landowners more than would have been required by other methods, in most instances. However, further investigation is necessary to determine the most economical maintenance methods and equipment for the various types of maintenance problems



trees. By using blocks, sufficient power is obtained to pull stumps and haul trees and logs from the ditches. Though dynamite is used to blast the large stumps, many of the small ones can be pulled with the tractor. These same features may prove an advantage to farmers having a tractor available for cleaning small farm ditches. Dynamite was used for rocks also, and often for heavy cuts where blasting was cheaper than scooping.

**Blasting.** Dynamite was first used to blast channels about 1897. Since then methods and materials have been greatly improved, and today it is generally recognized that explosives have a very definite place in both channel construction and channel maintenance. With the ditching dynamite now made, channels can be constructed of regular cross-section and true grade. In maintenance work, especially on large channels, conditions are very exceptional where dynamite is not considerably less expensive than hand labor.

In 1930, the E. I. du Pont de Nemours & Company, the Ohio State University, and the U. S. Department of Agriculture cooperated in carrying out experiments in channel cleaning with explosives in northern Ohio. There most of the deposits in the channel were a fine clay. The experiments showed that 1½ ft of material could be blown from the ditch for 25 to 35 c per cu yd. Where the depth was about 3 ft, the material could be blasted for about 10 c per cu yd.

Dynamite is much more effective in clay than in sand. In Kent County, Delaware, sand is the prevailing soil, and all the work thus far with dynamite has been experimental. Some very excellent results have been obtained by using about 1 to 1½ lb dynamite per cubic yard of sand excavation.

The channel shown in Fig. 3 was cleaned with a single row of charges in the center of the ditch. Each charge contained 5 lb of explosive, and the charges were set 6 ft apart and 34 in deep to the bottom of the load.

At present a series of experiments is being made to determine the best loading for sandy soils. In these experiments all dynamite is loaded through a metal casing, sunk by boring with an auger. The dynamite is tied in a bundle about a stick and lowered to the necessary depth. Uniform depth is a very important factor, and by this method we are able to obtain it very accurately. Space-depth relationships are being varied, and data now available indicate that this relationship is a controlling factor in results obtained. However, the work is not yet far enough advanced to draw reliable and definite conclusions.

One outstanding advantage of dynamite is the ease with which a large amount of potential power is transported. Where intermittent bars and collections of debris are to be removed, the use of the explosives greatly simplifies the power-transportation problem. Spoil banks along a ditch often flourish with rank growths of vegetation and

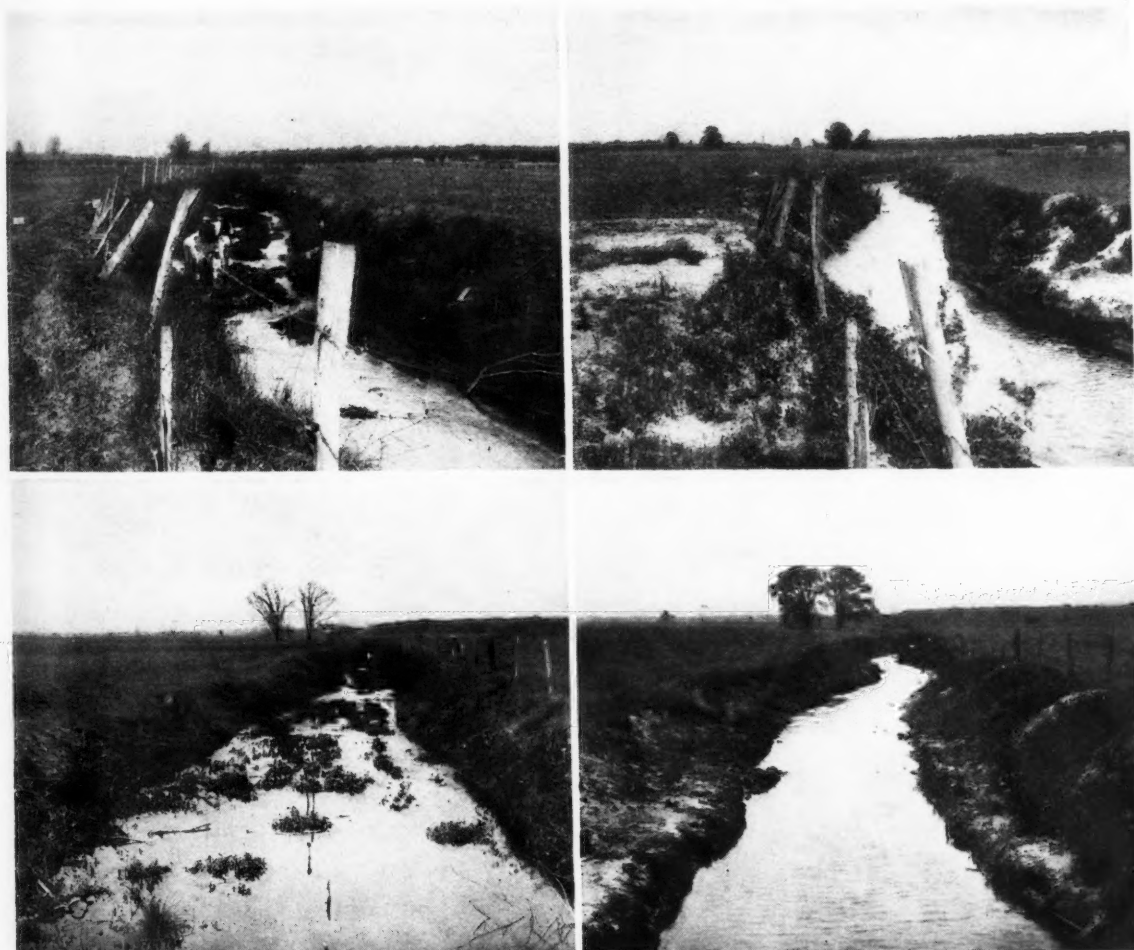


Fig. 3. Views both directions in a ditch before and after being cleaned with dynamite. The soil was sandy; the work experimental; and the loading, a single row of 5-lb charges set 6 ft apart and 34 in deep to the bottom of the load

are always a cause of concern to the farmer. Explosives scatter the excavated material and leave no appreciable spoil banks.

The power of dynamite is easily wasted. Proper concentration of the charges and space-depth relationships will vary for different soils and with different moisture contents of a given soil. Some knowledge of these relationships is essential in order to obtain efficient results.

There is considerable need for experiments to determine where, when, and how to use explosives to best advantage. Much useful information has been compiled by makers of explosives, but there is still a demand for information more thorough in detail and more comprehensive in scope, especially concerning loading methods for different classes of materials to be excavated.

As previously stated, dynamite has a very important place in any program or plan for efficient channel maintenance. Its use in the future will expand as more definite information is made available concerning the limits of its application as determined by efficiency, economy, and effectiveness.

**Dredge Work.** To compare costs of dredge work with other methods, a dredge with  $\frac{1}{2}$ -yd clam-shell bucket was rented for \$33 per day, including operator, gas, and oil. This machine worked 9 days and the cost of the work was 10 c per cu yd excavated. To the present there has been no work in a comparable section except by hand labor, which cost 84 c per cu yd. This dredge made a cut 3 to 4 ft deep with an average width of about 16 ft. Work of this type is more representative of construction costs than of maintenance costs.

Since the introduction of the dredge about 1885, much progress has been made in its development. Machines now on the market may be divided into three general classes—the suction dredge, the bucket or dipper dredge, and the elevator dredge.

The suction dredge has greatest application in river and harbor work, but seldom are conditions favorable for using it in agricultural drainage. It may be used to advantage where soil conditions are favorable and there is sufficient water.

Bucket or dipper dredges may use either the drag bucket, the grapple bucket, or the dipper. Some of them float in the ditch they are digging, some straddle it and run on a track placed along the ditch, and some are arranged with ingenious devices for lifting and throwing their weight along, or walking. Some excavating machines, particularly the older types, had to be dismantled in order to pass bridges, or to move from one job to another. The track-laying or apron-traction machines have largely overcome this disadvantage, and therefore are in considerable degree superseding the other types.

#### DREDGE DEVELOPMENT

The trend in development has been toward larger machines. For construction purposes this is desirable, but for maintenance purposes it is working in the wrong direction. With large machines, large quantities of material must be excavated in order to operate economically. To use a large heavy machine for removing a few inches of

silt and vegetation is not practical. Lack of a suitable light, low-cost excavator doubtless has been a considerable influence toward neglect of ditches until large amounts of material had badly congested them and made reconstruction necessary.

Very recently—even within the last two years—a number of small machines have been placed on the market. Most of these have buckets of about  $\frac{3}{8}$ -yd capacity and booms up to about 30 ft length. For general maintenance purposes the machine shown in Fig. 4 (left) is much more adaptable than larger machines. The need is for small bucket capacities, high traction speeds, and high digging speeds. Some improvements in bucket designs would also be desirable. Buckets for maintenance work can be lighter than those needed in construction work, because they do more dragging and trimming, and less digging.

The elevator dredge uses buckets mounted either on an endless chain or a revolving wheel. Of the two machines shown in Fig. 4 (center and right), the endless-chain type (right) is adaptable to greater variations in channel sizes. It was designed in 1907 in the West, and has been developed in that section for maintaining irrigation channels. It has a wide range of traction and digging speeds. As a general-purpose maintenance machine this type has features superior to other makes. Its adjustments for various sizes of channel and its adjustments in traction and digging speeds are the very essential features required in maintenance work.

One disadvantage of the endless-chain elevator machine is that on large ditches it must traverse both sides of the channel. In timbered sections this requires clearing of both banks. In sections where diversified farming is practiced, fences along the ditches interfere and moving these may be troublesome and costly.

#### SUMMARY

In recent years much improvement has been made in excavating machines suitable for the construction of open channels, and large investments have been made in systems of drainage and irrigation ditches. The life of open ditches, however, is very short in most soils unless they are kept reasonably free of sediment, debris and vegetation.

The experiments in ditch maintenance work in Delaware have shown that such work performed by hand labor has been costing the landowners more than would have been required by other methods, in most instances. However, further investigation is necessary to determine the most economical methods of performing such work, and further experiments to determine the most suitable maintenance equipment.

Excavators with higher traction speeds would be desirable, and our work in Delaware indicates that lighter, wider, flatter buckets would be more effective in the removal of relatively small amounts of material and in obtaining a smooth ditch section. The equipment comprising tractor, cable and scoops has worked rather satisfactorily, and has the advantage of involving but rather little investment since it was not necessary to purchase the tractor just for this work.



Fig. 4. (Left) A modern small drag-bucket dredge, the central unit of which is a track-type tractor, (center) an elevator dredge with buckets mounted on a wheel, (Right) An elevator dredge with buckets mounted on a chain

# Field Curing of Hay as Influenced by Plant Physiological Reactions<sup>1</sup>

By T. N. Jones<sup>2</sup> and L. O. Palmer<sup>3</sup>

**W**HILE MUCH WORK has been done on the curing of hay both artificially and by improved field methods, the relationships between the fundamental factors involved have not been determined. The Mississippi Agricultural Experiment Station has undertaken a study with the object of determining the factors involved in the curing of hay and their relationships, paying particular attention to plant physiological reactions. This paper is a report of progress in this study.

A review of literature dealing with engineering methods of hay curing indicated the need of more information concerning the physiological reactions of the hay plants to curing processes. A cooperative agreement was therefore made with the plant physiology department of this station to make a study of these plants and their reactions to different methods of handling and curing. The procedure consisted essentially of curing hay in the field by different common methods, measuring the factors involved in curing and then determining the interrelationships between these factors and the condition of the hay. Hay was cured by the following methods:

1. In the swath
2. In single and double windrows raked (a) at time of cutting, (b) 2 hr after cutting, and (c) 4 hr after cutting
3. Crushed and uncrushed.

Measurements of certain factors were made during the curing process and studied by the multiple-correlation method. The external factors studied were heat (which took into account air temperature), soil temperature, moisture and hay temperature, relative humidity, and wind velocity. The internal factors studied were amount and kind of water to be removed and plant structure.

**Reaction of Stomata.** A large proportion of the water lost from a plant is through the stomata. The report of Loftfield<sup>4</sup> shows the results of several counts made of the number of stomata on living plants open during different periods of the day. He found that they began to open at 5:00 a m and reached a maximum of opening at noon, at which time they began to close rapidly, having a minimum of opening at 2:00 p m. From 2:00 p m to nightfall, the stomata gradually open. This would indicate a physiological periodicity in the plant, apparently not entirely due to external influences, as temperature increases and relative humidity decreases until about 4 o'clock. These facts should have some influence on time of cutting, curing, and raking, but this study has not been carried far enough to make definite recommendations.

During the season a study of the rate of closing of stomata on alfalfa hay cured by different field methods was made. The accompanying table gives the results obtained. Each figure in the table is an average of fifty counts or more. The data from the table show a marked relationship with that of Loftfield, there being, at the time the plant was cut, a difference of only 3 per cent in his count and that made at this station. The leaves for these

counts were taken from plants in similar positions and placed in a suitable fixative for preservation in the condition existing at the time of taking. In order to make the counts, the leaves were embedded in paraffin and transferred to slides for a microscopical study of the condition of the stomata. The data indicate that the stomata close very rapidly for the first two hours after cutting.

**Comparative Rate of Curing.** Results of the studies of the rates of curing by the different field methods indicate that double-windrowing two hours after cutting furnished a cured hay with a more desirable color, a larger percentage of leaves remaining on the stems and a lower moisture content at the end of the day due to the continuous activity of stomata. The windrows as raked with the side-delivery rake were rolls of an average diameter of 1½ and 3 ft, respectively, for single and double, and the samples taken consisted of a full cross-section of the roll so that it would be representative of all the hay within the windrow.

In both sizes of windrows the loss of moisture was less than that in the swath for the first 2 hr, but this hay dried more uniformly and reached a lower moisture content by 5 o'clock in the afternoon, which was 8 hr after cutting. (Figs. 1 and 2.) The hay in the swath at the end of this period had been reduced to a moisture content of 31 per cent, while the hay in the single and double windrows raked at time of cutting contained 29.0 and 30.5 per cent moisture, respectively. This gave a moisture loss in excess of the loss in the swath of 2 per cent for the single windrow (Fig. 1) and 0.5 per cent for the double windrow, (Fig. 2).

When allowed to cure in the swath until 11 o'clock, 2 hr after cutting, and then windrowed, the hay in both double and single windrows lost more moisture than that which was windrowed at the time of cutting; the single windrow (Fig. 1) reaching 28 per cent at the end of 8 hr, while the double windrow (Fig. 2) reached 24 per cent at the end of the same period. The hay in the single windrow raked at this time reached a moisture content one per cent lower than that which was single windrowed as cut, whereas that of the double windrow reached a moisture content 6.5 per cent lower than that which was double windrowed as cut.

For the sizes of windrows raked as cut there was a difference of 1 per cent in the moisture loss at the end of 8 hr, in favor of the double windrow. When raked at 1 o'clock, 4 hr after cutting, the hay in the single windrow was reduced to a moisture content of 27.5 per cent, while that in the double windrow reached 23 per cent. This gave hay with only 0.5 and 1 per cent less moisture in the single and double windrows, respectively, by allowing a 4-hr instead of a 2-hr exposure to the sun in the swath.

The lowest average moisture content reached for a day's period, 8 hr after cutting, under the various conditions, was 31 per cent for the swath, 27.5 per cent in the single windrow, and 23 per cent for the double windrow, (Figs. 1 and 2).

A marked difference was observed in the amount of dew which collected on the hay at night. The period here considered as night was from 5:00 p m, 8 hr after cutting, until 5:00 a m, 20 hr after cutting. The curves (Figs. 1 and 2) show that the hay under the several conditions increased in moisture content very rapidly on account of the condensation of dew, reaching the peak with very little irregularity in all cases at 5:00 a m. The increase in moisture content was an average of 33 per cent for the swath, 23 per cent for the single windrow, and 23 per cent for the double windrow. After 5:00 a m, 20 hr after cutting, the curves indicate that the removal of dew from the hay

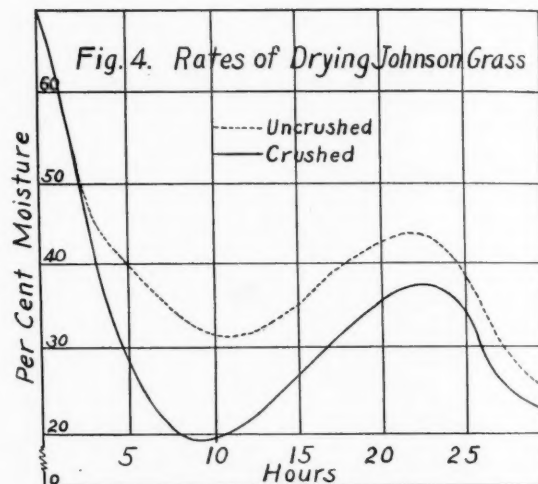
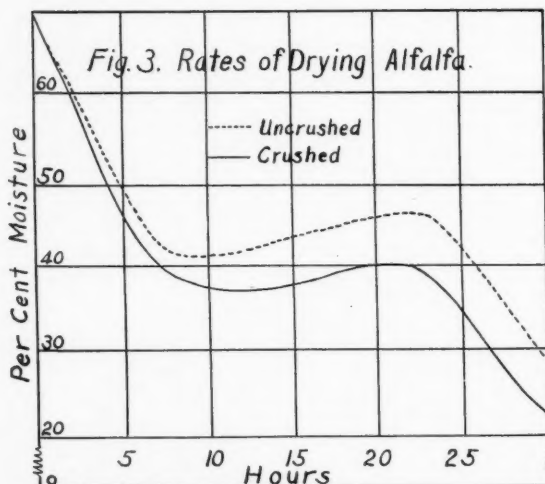
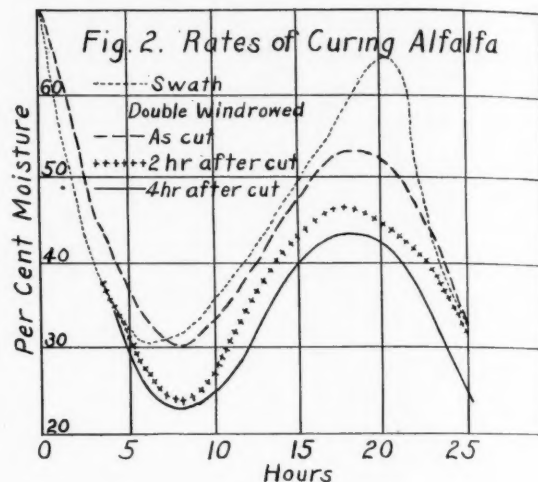
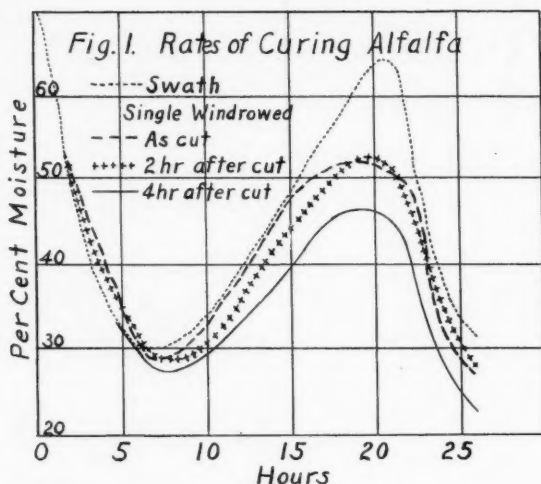
<sup>1</sup>A progress report on results of research work at the Mississippi Agricultural Experiment Station being conducted by the agricultural engineering department in cooperation with the plant physiology department. Released for first publication in AGRICULTURAL ENGINEERING.

<sup>2</sup>Agricultural engineer, Mississippi Agricultural Experiment Station. Assoc. Mem. A.S.A.E.

<sup>3</sup>Plant physiologist (graduate student), Mississippi Agricultural Experiment Station.

<sup>4</sup>Carnegie Publication No. 314, 1921.





These curves show data taken in the studies at the M.A.E.S. on field curing of hay by machine methods as influenced by plant physiological reactions

was no more rapid than the removal of the initial plant moisture. This indicates that hay should not be left in the swath or windrows over night. It should be in a position which leaves the smallest amount of surface exposed.

**Crushing Alfalfa.** Fig. 3 shows the results obtained by crushing alfalfa hay before curing under Mississippi conditions. There was a difference of 4 per cent in moisture content between crushed and uncrushed hay at the end of a 10-hr period. This is hardly sufficient to justify crushing. The crushing caused the stems to be broken down and the moisture exposed on the surface so that drying was more rapid.

**Crushing Johnson Grass.** Results obtained with the crushing of Johnson grass (Fig. 4) gave a moisture content of 20 per cent for the crushed hay at the end of an 8-hr period as compared with 32 per cent for the uncrushed. This difference of 12 per cent in favor of crushing indicates the possibilities of this process and its value to the Johnson grass hay industry.

There is no record of such work with Johnson grass available, but it is the opinion of the authors that with more thorough crushing the moisture content can be reduced to that of commercially dry hay at the end of a period of 8 to 10 hr. The crushing should be of value in making the hay more palatable as well as retaining the chlorophyll or green coloring due to the shorter period of exposure to the sun.

Reducing the time required for curing from two or three days to one day reduces the hazards of rain to a minimum. In this section where rains are frequent during the summer months, this is a factor of much importance.

#### SUMMARY

1. Alfalfa double windrowed 2 hr after cutting seems to give the most desirable cured hay.
2. Reaction of stomata on cutting hay indicates a physiological periodicity in the plant apparently not entirely due to external influences.
3. Stomata open and close periodically.
4. Data indicate that hay should be left in a position with the smallest amount of surface exposed over night.
5. Crushing hay reduces time required for curing.

Rate at Which Stomata Close in Alfalfa After Cutting  
(Cutting made at 9:30 a m)

Time taken	Open, per cent	Partly closed, per cent	Closed, per cent
As cut	63.26	36.74	0.00
1½ hr after cutting	8.00	80.00	12.00
2 hr after cutting	1.20	60.12	38.68
3½ hr after cutting	2.59	85.71	11.70
5½ hr after cutting	3.49	53.91	42.60
6½ hr after cutting	0.34	40.95	58.71

# The Dynamic Properties of Soil<sup>1</sup>

## III. Shear Values of Uncemented Soils

By M. L. Nichols<sup>2</sup>

IT HAS ALREADY BEEN SHOWN that practically all tillage machines consist of devices for applying pressure to the soil<sup>3</sup>. In many machines the pressure is applied by means of inclined planes or wedges moving in a path parallel to the soil's surface. As the implement advances, the soil in its path is subjected to a compressive stress which, in an uncemented soil, results in a shearing action as a block of soil is forced by the pressure of the advancing surface to slip upward and forward.

This reaction is evident to the observer of such tools as cultivator shovels. In the case of the plow the same general reaction occurs, but is more difficult to observe due to the lateral vectors of force, or the twisting action of the moldboard, and the fact that shear planes of soil are not always distinct or easily noticed areas of reaction. The shear reaction becomes obscure when a moist soil is covered with a thick mat of sod, is in a plastic condition, or when it is dry and uncohesive, a condition common in light sandy soils.

The foregoing described reaction was found to occur in all uncemented soils studied<sup>3</sup>. It is of great importance because it means that the horizontal components of the pressures applied to the soil can not exceed the shear value or the force necessary to cause a block of soil to break loose and slip upward and forward in the line of travel of the implement. Although the complete relationship between the soil shear value and the draft of an implement has not been established, it is of considerable importance. The amount of force necessary to produce shear in various uncemented soils and the general nature of the

reaction have been determined in over 1500 tests. The findings are summarized in this paper.

**Nature of Shear Reaction.** The term "shear," as used here, means the reaction of the soil to external forces, in which two contiguous parts of a body of soil slide over each other in a direction parallel to their plane of contact. The forces resisting shear may be divided into two parts, internal friction and cohesion. This reaction may extend for a considerable distance on either side of the shear plane due to cohesion and the interlocking of particles.

When the blocks of soil being sheared apart are not definitely separated by an air space and when sufficient moisture is present, the water films on the soil particles may immediately bind the soil together again with the same cohesive force existing before the shear occurred. In cases of high moisture content the shear area may even be more highly cemented on drying than other areas due to "puddling" effects.

**Experimental Methods.** The apparatus used in the study of shear is shown in Fig. 1. This consisted of a cylinder (A) 5 in high and 6 in in diameter, mounted in a press in such a manner that the soil could be confined at any desired pressure. The pressure was applied by means of a screw and plunger (B) which fitted the top of the cylinder. The pressure on the soil was measured by a Goldbeck gage (C) which closed the entire base of the cylinder. The cylinder was cut so as to form three rings. The lower ring was one inch in height and each of the upper rings were 2 in in height. The lower and upper sections were fastened securely in place and the center section hinged so that it could swing out by means of a lever (D). When the center section was swung out, the compressed soil was "sheared" at the upper and lower surfaces of the hinged ring. In the preliminary studies the lever was pulled by the crank and windlass (E), and the pull measured by a calibrated spring. The leverage being known as well as the number of square inches of shear area, the shear in pounds per square inch could be determined.

Even with this simple apparatus difficulty was encountered in getting exact values, as the soil would compress in front of the moving section before it would shear, i.e., under pressures of the magnitudes to be expected in field soils. This meant that the area of actual shear was varying, and the value obtained was too low when calculated on the square inch basis. This difficulty was overcome by substituting an electric torque dynamometer for the hand windlass and recording both the pull and movement by a clock-driven kymograph. This gave a complete record of the action

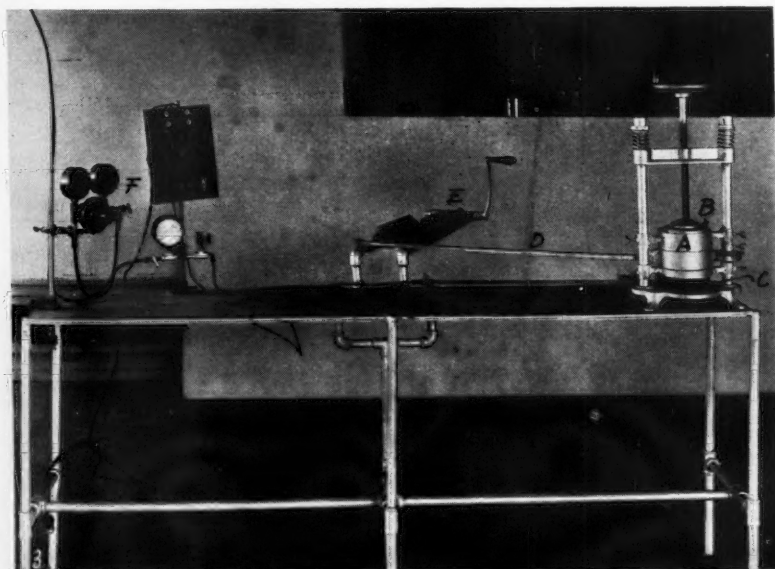


Fig. 1. This picture shows the apparatus used in the studies of the shear values of uncemented soils at the Alabama Agricultural Experiment Station

<sup>1</sup>Third of a series of articles setting forth the results of ten years of original research work in soil dynamics at the Alabama Polytechnic Institute. Released for first publication in AGRICULTURAL ENGINEERING. Part I was published in the July 1931 and Part II in the August 1931 numbers of AGRICULTURAL ENGINEERING.

<sup>2</sup>Agricultural engineer, Alabama Polytechnic Institute Agricultural Experiment Station. Mem. A.S.A.E.

<sup>3</sup>Nichols, M. L. Methods of Research in Soil Dynamics as Applied to Implement Design. Alabama Experiment Station Bulletin No. 229, 1929.

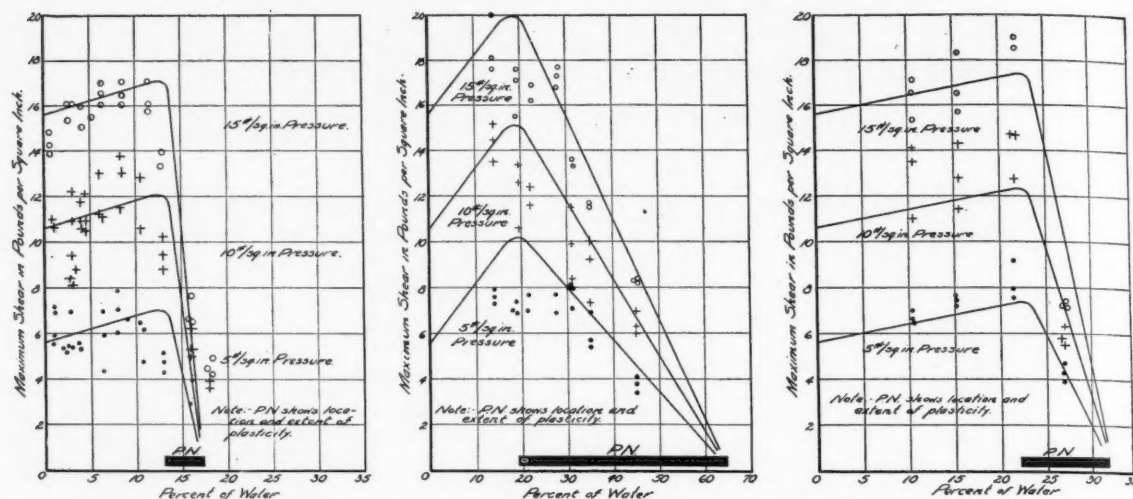


Fig. 2. (Left) Shear values of Cecil clay at different moisture contents. Lines show values calculated by formulas. Dots show actual tests. Fig. 3. (Center) Relation of shear value of Lufkin clay to moisture contents. Lines show values calculated by formulas. Dots indicate test results. Fig. 4. (Right) Relation of shear values to moisture contents for black clay loam. Lines show values calculated by formula. Dots indicate actual tests

during the entire movement of the lever and enabled the shear per square inch to be calculated at any moment.

The variations in shear values through a wide range of moisture contents were determined for two series of soils. The first consisted of a series of synthetic soils composed of mixtures of Cecil clay and pure sand and the other a series of field soils varying in plasticity. The field soils were Lufkin, Susquehanna, Sumter, and Cecil clays; a black clay loam from Aledo, Illinois, experimental field, and Wooster silt loam. Mechanical analysis of all soils were made and the plasticity constants determined. The constants considered were the lower plastic limit, the upper plastic limit, and the plasticity number.

Moisture was applied to the soils by the condensation method and measured by determining the loss of weight on drying. Shear tests were made in triplicate at three pressures—5, 10, and 15 lb per square inch for each moisture content used.

**Shear of Plastic Soils.** Table I shows that the shear values of plastic soils were proportional to pressure. This was true at all moisture contents. A number of determinations were made with pressures up to 30 pounds per square inch, and the same proportions were found to hold for the soils studied. It was concluded that this would be true for all pressures of the magnitude of those applied by tillage implements.

The shear values for all the soils studied were plotted on coordinate paper with the moisture percentages as abscissas and the shear values in pounds per square inch as ordinates. Figs. 2, 3, and 4 give the results for Cecil and Lufkin clays and black clay loam obtained from Aledo, Illinois, experimental field. These are typical of all curves obtained for plastic soils. It will be noted that the shear value increased to a certain point on the moisture scale and then decreased. In all plastic soils the maximum shear value occurred at a moisture content very close to that of the lower plastic limit. This is approximately the moisture content of maximum cohesion and is probably due almost entirely to this property, for at higher moisture contents, which permit even a greater packing at the same pressures, the shear value is less. There is, moreover, no reason to assume that the interlocking of particles or internal friction should increase with moisture content, except as cohesion affects this relationship. Figs. 2, 3, and 4 indicate that the relationship of rising and falling shear values to moisture content is considered as linear. Within the moisture ranges studied, it appeared that straight line formulas would come nearer to expressing the relationship for all soils studied than any other and they were accepted as a basis for practical calculation.

In considering the practical application of any formula involving moisture content, it should be borne in mind that the water for these experiments was applied by the condensation method, which gives a very uniform distribution throughout the soil. Under natural conditions of wetting, or conditions approaching those found in the field, this does not occur and the force relationship undoubtedly will vary at the same general moisture content depending upon whether the soil is being wetted or dried. These force variations at the same moisture content were quite carefully studied by Haines<sup>4</sup> who showed that the "pressure deficiency," a measure of film force, could be practically constant with varying percentages of moisture depending upon the distribution of moisture over aggregate particles.

It has been stated above that shear value was proportional to pressure. With moisture contents up to the lower plastic limit this proportion was quite constant for all plastic soils. The average value found was 1.04 lb increase in shear value for each pound of increase of pressure. For practical purposes this may be considered as directly

<sup>4</sup>Haines, W. B. Studies in the Physical Properties of Soils. V. The hysteresis effect in capillary properties and the modes of moisture distribution associated herewith. Journal of Agricultural Science 20. Pages 97-116. 1930.

Table I. Shear Values of Soils at Different Pressures in the Lower Moisture Ranges

Soil	Moisture content, %	Shear value in lb per sq in at different pressures		
		5 lb	10 lb	15 lb
Cecil $\frac{1}{2}$ sand $\frac{1}{2}$	2.88	5.10	10.21	15.06
Cecil clay	2.60	5.50	10.90	16.00
Wooster silt loam	7.80	8.63	13.74	18.15
Black clay loam*	15.00	7.60	12.75	17.30
Susquehanna clay	13.00	6.85	11.94	17.01
Sumter clay	15.80	8.48	13.75	18.50
Lufkin clay	18.70	7.85	13.87	18.57

\*A black clay loam from Aledo, Illinois, experimental field



proportional since this is within the experimental error involved in determinations of this kind.

The maximum value of shear at any pressure was also found to be proportional to the plasticity number. This is shown in Fig. 5 for the series of plastic soils under 15 lb pressure. The equation for the line expressing this relationship is

$$F_{ms} = 0.066 P_n + 16.8 \quad [1]$$

where  $F_{ms}$  is the maximum shear value at 15 lb pressure,  $P_n$  the plasticity number, and 16.8 the shear value of a soil with the plasticity number of zero. Since the shear value was found to increase one pound for each pound of increased pressure, the maximum value at any pressure may be found by writing Formula 1 as

$$F_{ms} = 0.066 P_n + P + 1.8 \quad [2]$$

where  $P$  is pressure in pounds per square inch and the other symbols have the same meaning as in Formula 1. The significance of the constants is not entirely clear, but tests of dried soils passed through various sized sieves indicate that they are largely dependent upon the state of aggregation of the particles. This would, of course, mean that the shear of plastic soils would be materially affected by flocculating or dispersing agencies. In field soils the inclusion in the soil mass of a large number of soil aggregates or other coarse material having various shapes, would produce a similar effect, and shear values derived from formulas based upon any soil constants must in practical application be considered as approximations.

When the lines representing the rise of shear value with moisture for each plastic soil were plotted on the same coordinate paper it was found that the lines for each soil, if extended to the Y-axis, i.e., zero moisture, would meet at the same point. Dry samples for each soil were, therefore, taken and the shear value determined. It was found for all plastic soils, when the soil was put through sieves (80 mesh) sufficiently fine to remove coarse sand and aggregate particles, that at 5 lb pressure the shear value was 5.6 lb per square inch; at 10 lb pressure, 10.6 lb per square inch, and at 15 lb pressure, 15.6 lb per square inch. When larger particles were left in the dry soil the shear values varied, apparently being determined by the interlocking of the larger particles and cemented lumps.

Since the shear value increases proportionately to pressure at the rate of one pound per square inch for each pound pressure, and the shear values for 5, 10, and 15 lb pressure are 5.6, 10.6, and 15.6 lb, respectively, it follows that the shear for no pressure would be approximately 0.6 lb per square inch. This figure can not, of course, be verified experimentally, but it is of value in calculating approximate shear values.

From the foregoing findings the shear at any moisture up to the lower plastic limit may be calculated by the formula

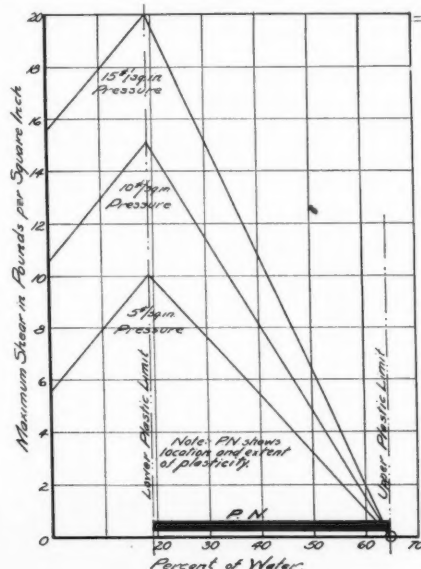
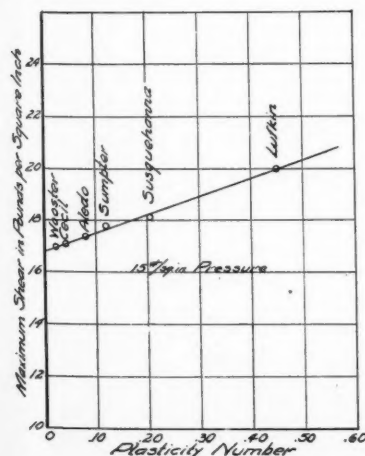
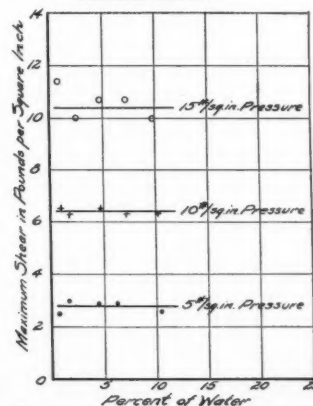


Fig. 5. (Left) Relation of plasticity number to maximum shear value at 15 lb pressure. Fig. 6. (Center) Diagram for estimating shear value. Fig. 7. (Right) Relation of shear value to moisture content of sand free from colloidal matter



$$F_s = \frac{0.06M}{P_l} (P_n + 20) + P + 0.6 \quad [3]$$

where  $F_s$  is shear value in pounds per square inch,  $M$  the moisture content in percentage,  $P_l$  the lower plastic limit,  $P_n$  the plastic number, and  $P$  the pressure in pounds per square inch.

At moisture contents beyond the lower plastic limit the soil properties change and shear gradually changes into "pseudo-viscosity," and, finally, at high moisture contents into viscosity. Shear value is proportional to pressure at moisture contents beyond the lower plastic limit, but the proportion varies at different moisture contents (See slopes of lines in Figs. 2, 3, and 4). For practical purposes at these moisture contents, the shear moisture relationship may be considered as linear.

The lines showing the moisture-shear relationships (Figs. 2, 3, and 4) at different pressures slope from their maximum value to the same point on the X-axis. This point with the more plastic soils is slightly above the upper plastic limit. There is a striking similarity between the convergence of these lines and the results obtained by Keen<sup>5</sup> and his associates at the Rothamsted Station from their work with soil pastes. Since at higher moisture contents the soil is in a semi-fluid condition and since both shear values and Keen's measurements of plastic flow are stress measurements it is evident in both cases that the same natural laws are concerned. This would mean that the soil constant termed "static rigidity" could be used as a more exact index of this part of the shear reaction for highly plastic soils.

For practical work the variations in shear with moisture of the highly plastic soils in this range may be approximated by connecting the point of the maximum shear, as previously described, with a point whose location on the X-axis is approximately that of the upper plastic limit. The formula for determining the shear at any point then would be

$$F_s = \frac{(P_u - M)}{P_n} (0.06P_n + P + 1.8) \quad [4]$$

where  $F_s$  is shear value,  $P_n$  the upper plastic limit,  $M$  the moisture content in percentage,  $P_n$  the plasticity number, and  $P$  the pressure in pounds per square inch. The shear of a soil having a low plastic number cannot be accurately determined in the higher moisture ranges by any plasticity-constant formula due to the predominance of coarse particles. Fortunately this moisture range is of little importance in practical tillage.

<sup>5</sup>Keen, B. A. The Physical Properties of Soil. Longman, Green and Company. Pages 147-169. 1931.

**Graphic Determination of Shear Value in Plastic Soils.** The approximate shear value in pounds per square inch may also be determined from the Atterberg plasticity constants for any plastic soil at any pressure or at any moisture content by constructing a diagram as follows: (See Fig. 6.) On a piece of coordinate paper lay off the ordinates to represent shear values and the abscissas to represent percentages of moisture. The shear of any dry soil in uncemented condition at zero pressure is approximately 0.6 lb per square inch. This increases one pound per square inch for each additional pound of pressure. Therefore, the pressure,  $P$ , in pounds plus 0.6 equals the initial shear value at zero moisture. The maximum shear occurs at the moisture content of the lower plastic limit and the maximum value at this point may be found from Formula 2. These values give the coordinates of the maximum value. To complete the diagram join the shear value at zero moisture with this point, and then connect the point of maximum shear with the moisture content of the upper plastic limit. From this diagram the shear value at any moisture can be determined.

**Shear of Non-Plastic Soils.** The general results of shear studies of non-plastic soils have been set forth in a previous publication\*.

The colloid content was found to indicate the place and value of maximum shear reaction of synthetic soils. There is some question as to the advisability of using colloid content instead of clay content, as both of these factions are proportional to the amount and place of reaction in a series of synthetic soils. Joseph<sup>†</sup> found that the entire clay content as determined by centrifuging may, in some cases at least, be obtained in the colloidal form. Bayer<sup>‡</sup> found that the relationship of plasticity number to clay content was linear, thus indicating the advisability of using the clay content instead of the colloidal content as an index to a soil's reactive properties. These facts deserve careful consideration, but since the total clay content of any non-plastic soil is low and the slope constant in the formula (Formula 5) is small, it is questionable if the error introduced by variations in methods of dispersing would be as great as the error involved in practical calculations due to the variations of the soil in any particular field. Moreover, it should be noted that the slope constant would be decreased proportionally to the colloid-clay ratio, so that, with uniform methods of dispersing, the use of the colloid as an index would not necessarily involve an error. For these reasons the colloid content will be used as an index until further investigation determines which of the two indices is the better.

The place on the moisture scale of the maximum shear reaction for non-plastic soils was indicated by the equation

$$M = 0.3C + 5 \quad [5]$$

where  $M$  is the moisture content in percentage and  $C$  the colloidal content in percentage. Since the moisture content of maximum activity varies with the surface demands of the various colloids, this formula merely furnishes an approximation of the true moisture content of maximum shear.

It was also found that the maximum shear value at 15 lb pressure could be found from the equation

$$F_{ms} = 0.2C + 10.5 \quad [6]$$

where  $F_s$  is shear value in pounds per square inch and  $C$  the colloid content in percentage. From this formula it appears that sand having no colloidal material would have a maximum shear of 10.5 pounds per square inch. Formula 6 and the reactions of plastic soils indicate that the colloidal content produced the variations in the shear value in soils from which it may be deduced that the shear value of pure sand would be practically constant at all moistures.

\*Nichols, M. L. The Dynamic Properties of Soil. I. An explanation of the Dynamic Properties of Soils by Means of Colloidal Films. AGRICULTURAL ENGINEERING, Vol. 12, No. 7 (July 1931). Pages 259-264.

†Joseph, A. F. The Determination of Soil Colloids, Soil Science, 24, 1927.

‡Bayer, L. D. Unpublished data included in correspondence. Soils Laboratory, University of Missouri.

This was found to be the case as shown in Fig. 7. It was concluded from the tests of sands that their shear values were largely due to the interlocking of coarse particles and were little affected by adhesion. Fig. 7 also indicates that the shear of the sand used increased approximately 0.6 lb. per square inch with each pound increase in pressure. With the addition of colloidal material this value increased until at approximately 15 per cent colloid (approximately where plasticity commences) the ratio was close to 1.0. There was little variation in this pressure shear ratio with larger amounts of colloid. For practical evaluation it was considered that the value (0.7 lb) could be used for non-plastic soils.

When the non-plastic soils contained appreciable amounts of colloid material, the shear value increased with moisture content to a point indicated by Formula 5 and to an amount indicated by Formula 6. From this point the shear decreased as moisture increased, but not as greatly as with that of plastic soils because the moisture apparently produced a lubricating effect rather than an approach towards viscosity. This probably means that an exact evaluation of the shear value of non-plastic soils must include an evaluation of the effect of the interlocking of the larger particles considering size, shape, and roughness. This exceedingly difficult task was not attempted for it appeared that direct shear tests would be simpler than an evaluation based upon a complete mechanical analysis. Combining the effects of various pressures with Formula 6, the maximum shear value for any non-plastic soil may be approximated by the formula

$$F_{ms} = 0.2C + 0.7P \quad [7]$$

where  $F_{ms}$  is the shear value in pounds per square inch,  $C$  the colloidal content in percentage, and  $P$  the pressure in pounds per square inch.

Shear tests of several field soils were made to determine how close these formulas would predict the shear value. The calculated shear value on soils containing coarse sand checked quite closely with the actual determination. The shear of one soil, however, containing a large quantity of very fine sand or coarse silt varied nearly 20 per cent from the calculated value. Keen<sup>§</sup> found that the draft of plows and other implements varied as widely in different parts of a field which was considered fairly uniform. From this it was concluded that the formula was sufficiently accurate for a practical evaluation of the shear of non-plastic soils containing quantities of coarse sand, but for those composed largely of fine sand or silts the indicated shear value is too low.

#### SUMMARY

It was found that the shear value of any plastic soil was proportional to pressure. The maximum shear value of any plastic soil was proportional to the plasticity number. The maximum shear occurred at a moisture content approximating that of the lower plastic limit. The shear decreased from this point to a point near the upper plastic limit. The relation of increasing and decreasing shear to moisture content was found to be linear. These relationships were evaluated for a series of plastic soils and are suggested as a basis for calculating the shear values of other plastic soils by means of formulas and diagrams.

Shear values of non-plastic soils were also studied and the reaction was found to be similar to that of plastic soils when the soil contained appreciable amounts of colloidal material. Pure sand showed no appreciable increase in shear value with increased moisture content. It was concluded that the shear value of the non-plastic soils depended to a large degree upon the size, shape, and smoothness of the coarse particles, and therefore could not be approximated with the same degree of accuracy as the shear value of plastic soils which take these properties from a predominate quantity of very small and comparatively uniform particles. Formulas derived from the soils studied for approximating the moisture content of maximum reaction and maximum shear value based upon the colloidal content, are included as the best available material for estimating the shear value of a non-plastic soil.

# Engineering Leadership as a Policy for Agriculture<sup>1</sup>

By Arthur Huntington<sup>2</sup>

**N**OTWITHSTANDING our boasting of progress, the whole world is suffering from a hysteria based upon organization in restraint of trade, whereas the whole machinery of production has been geared to a mass-production program with minimum cost as the objective.

For more than a century the engineer has been revolutionizing the methods of producing raw material and processing it into usable products, yet he has made little progress in the field of distribution. He has created mass production, but seemingly has given little thought to mass distribution and mass consumption.

As a producer he has lived in a realm of progressive thought and action, but as a distributor of the products which he and his machine have created he has been content to accept the leadership of men who think and live and try to stabilize by using methods and practices of the past, the leadership of men who become panicky when their methods prove inadequate or new problems appear.

The engineer, accustomed to progress, has not learned that in time of depression, the more timid bolt and run and by their very weakness and lack of stability become leaders of a stampede. He has even failed to build up a defense for his contribution and now finds himself and his work being attacked by those who have benefited most. He finds himself the largest contributor to the civilization of his time, standing alone on account of his very stability, while business practices and public sentiment are being directed by those who have failed in their leadership.

Shall we stand by and let people suffer from want, in the midst of plenty, and permit those who clamor "surplus" and counsel organization in restraint of trade to continue the direction of our economic affairs, or shall we assume leadership and create methods of distribution commensurate with our ability to produce?

Shall we permit surpluses to accumulate when needy people are willing to buy but are unable to pay on account of a mal-distribution of the benefits of our ability to produce?

Shall we submit without protest to the theory that the benefits of mass production are for the trade advantage of a few Occidentals, or shall we become a factor in raising the economic status of those people who are, on account of improper equipment, forced to produce and consume on a basis of bare existence?

Has the engineer's contribution been in the interest of capital returns or higher living standards?

There are at present four groups, one of which will assume leadership in shaping our economic readjustment:

1. The politician, who has contributed little to the present condition and is likely to contribute even less to its solution, is as never before creating the machinery of governmental meddling.
2. The business man, who thinks of production based on his present ability to market rather than of creating marketing machinery suited to our ability to produce and consume.
3. The Socialist with his menacing policy of "Destroy until equality is created."
4. The engineer who, by creating machinery of production beyond the capacity of our business machinery to market, has upset our economic balance and in so doing

became one factor in causing our present economic distress.

Which of these groups is best suited for leadership?

The first three are fighting for leadership, while the engineer, best suited of all by natural endowment to think; best prepared by education; the most familiar with the machinery of creating, is shrinking from the responsibility of evaluating his work and apportioning the benefits of that which he has made possible.

It would be unfair to say that these men are not honest or patriotic, but it can truthfully be said that few of them have ever thought any problem through with all factors properly evaluated and that most of them do little more than attempt to verify their prejudices.

The fact that the engineer has an analytical, educated mind, with access to the facts, makes him more responsible for our economic condition than all of the other three groups combined.

Let us briefly consider a typical case. All during the decade from 1880 to 1890 it took approximately 150 bushels of wheat to pay for a self-binder. Today it takes approximately 300 bushels. To the layman that is a complete story and is both convincing and convicting evidence that there is a monopolistic trust which is gouging agriculture by extorting excessive profits. To him it is proof beyond controversy that the work of the engineer has been appropriated by a harvester trust for the benefit of capital without any benefit reverting to either the producers or consumers of wheat or to the benefit of the workers who produce binders.

Other major facts are seldom considered. When the self-binder and other labor saving equipment came on the market, it took from 5 to 7 man-hours to produce a bushel of wheat whereas today it takes from 10 to 20 min. In the eighties it took from 750 to 1000 man-hours to pay for a binder, whereas today it takes only from 50 to 100 man-hours. In the eighties the binder building departments of our factories worked from 2500 to 3000 hr per year making binders, whereas today few of them work for more than a few hundred hours. To make it possible to make binders at all, our implement factories have had to take on the manufacturing of a large line of agricultural machines, and at the same time create expensive sales agencies, finance corporations and experimental departments, and at the same time see dividends disappear and securities shrink to panic values on the stock exchange.

## DISTRIBUTION DEMANDS ATTENTION

This is a typical problem which is affecting our whole economic structure. What is true of binders is typical in the whole field of production.

The time has come when the engineer must use his skill and training to revolutionize the economics of distribution as he has revolutionized methods of production.

He must call a halt on the use of this equipment to make capital earn returns at the expense of the consumers. He must study the present apportioning of the benefits of mass production and work out more equitable ratios between capital return, upkeep and replacement of equipment, and the income of the workers. He must create a better balance between the machines and the men who direct them, and above all he must assume leadership in the relocating of those men whom machines have displaced.

For more than a century he has been putting dollars to work by replacing workers almost always to the benefit of the workers, but the time has arrived when he must turn

<sup>1</sup>An address before the 26th annual meeting of the American Society of Agricultural Engineers at the Ohio State University, Columbus, June 1932.

<sup>2</sup>Public relations engineer, Iowa Railway & Light Corp., Cedar Rapids, Iowa.



his creative skill to the creation of permanent pay rolls of operation. He must become a factor in the giving of our mass production methods to those nations which are hoping for and striving to attain living standards comparable with our own. He must teach them that equipment is valuable only as it is used to the benefit of all, that monopoly can only exist at a price so low that none can compete and then only when the benefits are passed on to the body politic.

Let us consider the five most dominant factors in production and the apportioning of the benefits. They are (1) better engineering, (2) better equipment, (3) better use of equipment, (4) better use of man power, and (5) better use of money. The first two are purely engineering; the third is the use of what the engineer has given; the fourth reflects the engineer through the equipment furnished to the worker; whereas money can be efficiently used only when the other four items are intelligently furnished and properly used. Such an analysis of these five items clearly points out the preeminence of the engineer.

#### OUTLET FOR QUANTITY PRODUCTION

But let us take another view. No matter how well the engineering is done or how efficient the equipment or how skillful the operators, efficiency and profits are impossible unless there is quantity output; in other words, the value of the engineer's work depends upon the man who is entrusted with the carrying of the benefits of production to the consumer, in other words the merchandising agent.

When looked at from this point of view, the engineer becomes a part of the factory equipment and the efficiency of the producing machinery is limited to business ability of the management and the selling department. It is limited to the capacity of men who think largely in terms of price without knowing much of the relationship which exists between quantity produced and cost; to the capacity of men whose first instinct is to call in salesmen and curtail production by shutting down machines and laying off men when the going gets hard.

Of course, there are men in the business world who, in addition to being executives are able to think and analyze. Likewise there are many engineers who are able executives and have a high sense of economic balance; men who not only know what has happened and what caused it to happen, but also are able to calculate with reasonable certainty what can be made to happen. There are many engineers who have the highest appreciation of equity in judging those things which ought to be made to happen and the equitable apportioning of the resulting benefits.

There is little to be gained by comparing some particular engineer with some particular merchant; there are successful men of the highest type in each group. There are many business men who have shown great skill in the selection of equipment and its arrangement, installation and operation after it has been selected. On the other hand, there are many engineers who have made an outstanding success in directing the use of equipment, man power and money. Many of them are great executives. In both groups we find many men who have been able to develop business in sufficient volume to make the whole venture efficient and profitable; men with the ability to direct the trend of an industry of which they are a part.

A more reasonably comprehensive comparison between the engineer and the business man as a leader in economic affairs can be had by comparing industries which are engineering-dominated with similar industries which are dominated by non-engineering-minded men.

Let us consider agriculture and public utilities, industries very similar in their economic structure, with similar financial, production and selling problems. In each industry the property is not sold; only the produce or service of the property enters into the channels of trade. Each has a long business cycle. Each has adequate and efficient equipment at his disposal. Each sells in a market where the price of the commodity produced is dominated from the outside. Each is subject to much political meddling. Each must grow by developing new uses and new markets.

Of these industries, land operation and electric light and power afford the simplest and most direct comparison. In the years 1912-13, the investment returns per dollar invested, fixed and operating expenses, were almost identical in each industry. The greatest difference between the two industries is in the life of the physical properties, which is all in favor of the land.

Prior to 1912 the income per dollar of invested capital was much greater in agriculture than in the light and power industry and the electric industry had the greatest operating expense. The advent of the steam turbine made the industries very comparable and they have remained so over a period of 20 years. To make the comparison more direct, let us take Iowa where the utilities are average size and little affected by consolidations and utility regulation, and where agriculture is in the highest stage of family-sized farm units. What is true in Iowa is true for the two industries in other states and the country as a whole.

The picture at the beginning of this 20-year period was as follows:

Agriculture	Electric Light and Power
The income per dollar invested capital in 1912 was 12.5 cents, and 13.2 cents in 1913.	The income per dollar of invested capital was 12.5 cents in 1912, and 13.2 cents in 1913.
Prosperous and tendered money at 5 per cent.	Struggling to finance the natural growth of the industry; paying 7 per cent for money.
Reaching for luxuries and accepting them as necessities.	Cutting costs and effecting economies wherever possible.
Financing by pledging basic property.	Financing by pledging profits.
Accepting the lurid promises of the politician.	Being attacked by the politician.
Booming the price of land on account of easy finance and the increasing commodity prices of farm products.	Reducing the base cost of electricity; increasing the load factor by developing new markets and new uses.
Agriculture organizing into co-operatives.	Consolidating into more efficient operating units through ownership and through holding companies.

During the 20 years, the two industries have developed often by pursuing opposite policies. Agriculture has de-



The engineer cannot escape the responsibility of directing the people who acquire his machines in their intelligent use

veloped the cooperatives as a purchasing and sales agency under the influence of political directors and used, where possible, public funds. Education, finance and relief agencies using taxpayers' money have been created with duties ranging from the provisions of the Smith-Hughes Act to those of the Federal Farm Board. On the other hand, the electric light and power industry has created a sales agency for selling its securities, current-using equipment, and new service. The holding company has been created to provide for the utilities services very similar to those which the Farm Board and other governmental agents are trying to give to agriculture.

Agriculture succeeded in carrying both land and commodity prices to the highest known levels. It has demanded, received, and gladly accepted more political tinkering than any industry. It has had built up for it government-supported and politically-directed boards and bureaus and farmer-directed cooperatives, all operating in restraint of trade and in the hope of price boosting, with the result that the income per dollar invested in the industry dropped to less than 6 cents in 1931 and has averaged only 11.33 cents for the whole 20-year period.

#### AGRICULTURE'S FOREIGN MARKETS

American agriculture has withdrawn from many markets and has permitted the American manufacturer to use his commodities to purchase the international exchange which formerly was purchased with our agricultural surpluses.

Stated briefly, American agriculture has, in a relatively short period, seen two important competitors develop, the most important of which is at home.

The American manufacturer, with strong financial and governmental backing, reinforced by an almost fanatical popular clamor for foreign trade, has preempted the right to purchase our international exchange. Much of these exports is agricultural machinery which is making foreign producers better able to produce food products on a competitive basis with American farmers.

In the electrical industry the engineer analyzed and directed development on the theory of a maximum of income at a minimum unit profit, hoping thereby to increase the income and profit per dollar invested, until in 1931 the returns per dollar of invested capital stood at 17 cents and the 20-year average has been 16.64 cents.

This disparity of returns is the more remarkable when it is remembered that farm commodities increased to 220 as compared to the 1913 index taken as 100, while the selling price of the kilowatt-hour has declined continuously, to less than 90 all during the war period, and to about 64 at present. On March first of this year, the farm index was several points above the corresponding electrical index.

The oft-repeated arguments of inflation, boom and deflation of agriculture, lose their weight under the analysis of fact. Assuming that there had been no land boom or land value inflation and that agriculture be given all of the benefits of war prices for its commodities, the 20-year average income would be only 16.27 cents per dollar invested, and the returns for the last four years would have been about the same as they have been. In fact for the last two years they would have been exactly the same.

At the present time (May 1, 1932), a comparison of the two industries, both in financial straits, is roughly as follows. Agriculture under the dominance of business and political leadership is clamoring for more political and financial tinkering, restraint in production, further withdrawing from the market, etc., hoping thereby to remove a surplus which has accumulated in a hungry world.

Agricultural finances are at a low ebb, and those who have made the industry both efficient and prosperous are being discredited. Those who counsel reducing the cost of production are being held up to ridicule by the politically created boards and bureaus which in turn on account of failure to help it are losing their hold on the industry. Refinancing is almost impossible and land holding by trust companies, banks and insurance companies is on the increase.

On the other hand, the engineering-dominated electrical industry is suffering less from depression than any of the major industries. Its growth has been checked. Little new financing has been handled, but refinancing is being done under more favorable terms and conditions than in 1912. The wave of political attack against the industry is receding, and the influence of the engineer is being felt by the holding companies and financiers.

What is true of these two industries is more or less true in all business and industry, namely, that industries are prosperous in proportion as they are led and dominated by men with engineering minds; by men who think and plan for the future. The statement can be further expanded by saying that nations are prosperous in proportion to the extent that they have accepted the engineer in the creation and stabilization of the production and distribution of wealth. Industries and nations weather depression largely in proportion to the engineer's influence. The last data available (Standard Statistics Company) states that, for the first quarter of 1932, 111 industrial firms show a decline in net earnings of 72.6 per cent, whereas the 14 utilities reporting showed a decline of only 12.5 per cent. Many of the utilities in which the engineer has been the dominant factor in management actually showed an increase in net income.

Further analysis shows that even in times of prosperity those industries which have been backward in the use of the engineer and equipment have suffered from low output, low wages, labor disturbances, political interference and low and irregular profits. On the other hand, when the engineer has been supreme there has been, as a rule, greater output per worker, higher wages per worker, better working conditions, less labor unrest, a more equitable balance between wages paid and value of product produced and less appeal to the governmental agencies for protection or regulation.

Where case examples are studied, the economic pre-eminence of the engineer seldom suffers from comparison. But each contribution of the engineer has created a whole group of new problems nearly all of which require a knowledge of what has happened, the forces which caused the change, and the effect of the change on other industries, plus the most important problems in our present economic depression, namely, the apportioning of the benefits of production and the reestablishing of the replaced worker.

#### PROBLEMS OF EFFICIENT PRODUCTION

Efficient production requires quantity production which in turn calls for mass consumption. But how can agriculture stay in the buying market where the output per worker is so low that only those with large capital accounts free from debt can purchase enough to enjoy a reasonable standard of living? How can the workers in the textiles enjoy a reasonable purchasing power even though they receive a very high percentage of the gross value of that which they produce as long as the factories in which they work are so poorly equipped that the output per worker is far below the average of other American industries?

When only a few factories were well equipped and efficiently operated, the mass buying power of poorly paid people made it possible to reap good profits on highly capitalized factory equipment, but as more and more factories became efficient, there arose the necessity of a better balance between the value of the product produced and income and purchasing power of the workers.

Just a glimpse of this problem. In 1913 wages were approximately 42 per cent of the value of the product produced. Between 1913 and 1922 this ratio increased to about 45 per cent and then began to decline, and by 1929 had reached a ratio of about 39 per cent. While there are many other factors, the difference in buying power as represented by 45 per cent and 39 per cent roughly represents the surplus production which has been so troublesome. Stated more briefly, our surplus is the direct result of underbuying power, which in turn is the result of the workers being unable to consume their proportion of production which hinges back on the fact that wages have

been too small a percentage of the value of the product. Displaced workers, until located, have no buying power.

The solution of these problems and more are as much the work of the engineer as is the creation and operation of machines, and every engineer both in his private practice and in his society activities should be turning his best abilities toward their solution.

The engineer has made machines available to all people; he cannot escape the responsibility of directing the people who acquire these machines in their intelligent use.

We as engineers are proud of our profession and point with pride to the structures we have built and machines we have made but we are all prone to forget that Cyrus McCormick's great contribution was not a machine which would harvest wheat. His best contribution was the creation of a "business machine" which made it possible to produce reapers in quantity and at a price which agriculture could afford to pay. He created a sales force and a system of financing. In short, he created economic practices which made it possible for other producers to pass on the benefits of their inventive minds, thus benefiting the whole economic structure.

Many engineers are and always will be the creators of structures and machines and will live in the realm of operation, while others are invading the field of economics. A decade ago it was almost heresy for an economist to think in terms of the engineer and few engineers would concede that apportioning the benefits of their machines was a part of their duties. Today there is no very sharp dividing line between the more advanced thinking economists and those engineers who feel that as engineers they must assume responsibility for those economic changes which their handiwork has been a factor in making.

The advisability of the engineer entering the field of economics may still be a subject for academic discussing, but the time is past when it will be questioned as a practical step to take. The step has been taken by many of our best engineers and others will take it, some by choice and others because changing economic conditions will draft them. As engineers, we of necessity are being forced to invade the field of economics. As engineers we must accept the responsibilities which are being placed on our shoulders.

## Controlling Moisture, Erosion, and Flood Water

By Gottlieb Muehleisen<sup>1</sup>

**A**FTER reading many technical articles and reviewing many illustrated schemes, which have been and are still running their course in the daily newspapers, magazines, trade journals, etc., I find the problems of erosion control and conservation of moisture very interesting. What really is wanted is some simple, inexpensive, and practical system to prevent and control erosion. We want to know what to do, who is going to do it, and where we are going to start. By controlling erosion, the moisture will be saved incidentally.

Here is my idea, 20 years old. Store and keep the surplus rainfall and melting snow water at home or near the area on which it falls.

Arrange the fields by operation, crop production, etc., to absorb as much of the rainfall and melting snow water as possible. Whatever is not absorbed should be stored in ponds built for that purpose. Ponds should be located near the highest elevation. In the depressions and ravines there should be enough ponds in size and number to retain the surplus rainfall at the higher elevations. In this manner some of the moisture will soak away and some will evaporate. It is my theory that an increase in moisture soaking away on the higher elevations will cause more springs and a steady flow of clear water from them to the creeks and rivers. Having many ponds scattered about will cause a more even evaporation, and that may bring about a more even rainfall.

Build ponds by starting at the head of any watershed first on the branch lines and then continuing the system down the stream. This will give every field enough moisture; and none will have too much at one time. Building ponds is mostly a labor problem, for material is available on the ground. Earth dams are perhaps the best, and may be built up with team and scraper, drag line by blasting, etc. Each pond should be provided with an overflow, by

setting a small pipe through the dam to regulate the pool level and to carry away the surplus water.

The cost of building dams to create ponds will vary, but for average conditions, it may be around \$50 per pond, or \$1.25 per acre. For example, to pond the run-off from an area as big as Buffalo County (Wisconsin) which has approximately 439,680 acres, counting out the lowland, would require 10,000 ponds. At the rate of \$50 per pond, it would cost somewhere around \$500,000, or about as much as it would cost to grade and pave 20 miles of standard highway.

It should be understood that there are no cost figures available, and the figures given above are based on my judgment. At any rate, whatever the cost may be, labor cost would be the largest factor to consider. The benefits derived would far exceed the cost in the way of controlling erosion, moisture, and flood waters.

I believe every land owner should interest himself in saving his land from the ravages of erosion, helping relieve the heavy flow of silt that feeds the streams and rivers beyond their capacity, and helping prevent disastrous floods which are largely caused by a rapid run-off and erosion.

The first settlers who located on the higher ground, made ponds to store water for their stock and for other uses. With the development of deep wells, the ponds decreased in number. The few remaining ones are filled with silt and washed out dams and are not maintained. The time is here when the practice of building ponds should be resumed for the purpose of controlling erosion and moisture. Building too many ponds under our present-day conditions would be almost impossible.

<sup>1</sup>Consulting erosion engineer, and president and general manager, National Soil Conservation Co. Mem. A.S.A.E.

This pond was built and is being maintained by the owner of this farm for the purpose of storing water for his stock. Furthermore, this land owner prevented serious erosion problems above and below the pond by preventing rapid run-off. This pond takes care of about 30 acres of watershed. The pond is about 100 ft in diameter and 6 ft deep. It attracts ducks, geese, and frogs. It also makes a safe and good recreation place for the children as a skating rink in the winter.





# The Ohio Fertilizer Placement Tests with Corn Planters<sup>1</sup>

By C. O. Reed<sup>2</sup>

IT HAS BEEN ESTIMATED that Ohio uses an average of 160 lb of commercial fertilizer per acre on 44 per cent of its annual corn acreage. Of this quantity, about 90 per cent, or some 160,000 tons, is applied in the row or to the hill, field experiments by the agronomists having demonstrated that such localized applications are generally more efficient than the broadcasting method.

Localized placement, however, has not been uniformly successful from the standpoint of returns. Suspicion has been rife that much of the so-called "burning" of corn has been due to poor relative placement of fertilizer and seed. Instances are recorded showing severe losses in stand where spot applications were made at the hill; and not infrequently the yield of the fertilized plots has been less than that of the check plots, even when light applications were used. The question has been: Can something be done to assure Ohio farmers a better return from their annual investment of 3½ million dollars in commercial fertilizers for corn?

About three years ago the departments of agronomy and agricultural engineering of the Ohio Agricultural Experiment Station began to tackle this problem cooperatively and rather vigorously in two distinct yet closely allied projects. The agronomists, with some assistance from the engineers, have been attempting to determine just what should be the relative placement of fertilizer and seed in hill applications to check-rowed corn. In this extensive study the fertilizer and seed are placed by hand according to the patterns shown in Fig. 1, and the position and quantity factors are definitely controlled. This project will be referred to in this paper as the "hand-placement tests."

The second project, carried on jointly by the agronomists and agricultural engineers, consisted of actual planting tests with various common makes of corn planters (1) to determine how various types of fertilizer depositors place fertilizer in respect to the hill of corn; (2) to determine the efficiency of these types, as measured by stand, height, and yield of corn; and (3) to furnish corn planter manufacturers with authoritative data which will serve as a guide to their efforts for further improvements in the

design of fertilizer depositors. This project will be referred to in this paper as the "corn-planter tests."

Inasmuch as neither of the projects has been completed, the remarks and data presented herein must be considered those of a brief progress report.

In the few moments allotted to this presentation, we have not time to explain in detail the technique or results of the hand-placement work, or opportunity to dwell upon the many interesting botanical, agronomic, and engineering relationships involved in the two projects. A brief description and summary of the hand-placement work appears in the May-June bimonthly publication of the Ohio Agricultural Experiment Station, in which the agronomists draw the following inference:

"The data, as a whole, appear to favor placing the fertilizer either in a circular band, approximately 2 in wide and 3 in inside diameter, or in two parallel lateral bands, each about 2 in by 8 in and separated 3 in, giving in either case a minimum horizontal distance of about ¼ in between the seed and fertilizer. As regards depth, the fertilizer bands should probably lie within a zone from ¾ in above to 1 in below the seed, the evidence being slightly in favor of the deeper placement."

It should be mentioned here that Prof. R. M. Salter, chief of the department of agronomy, and his assistants, Dr. E. E. Barnes and Dr. C. L. Thrash, are the men who made the hand-placement studies, while Prof. Salter, Dr. Barnes, and Dr. L. E. Thatcher are the agronomists who carried on the extensive agronomic studies involved in the corn-planter work.

The corn-planter tests have continued each year since 1929 with the following two-row, check-row machines used:

1929	1930	1931	1932
Deere	Deere	Deere	McCormick-Deering
McCormick-Deering	McCormick-Deering	McCormick-Deering	Black Hawk
Black Hawk	Black Hawk	Black Hawk	Case
Case	Case	Case	Moline
Massey-Harris	Massey-Harris	Moline	Rock Island
Superior	Superior	Rock Island	Hayes
	Moline	Hayes	Massey-Harris
	Rock Island	O.A.E.S. Special	
	O.A.E.S. Special		

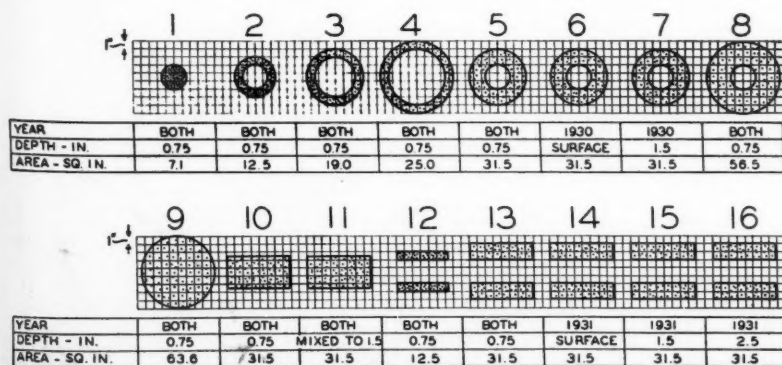
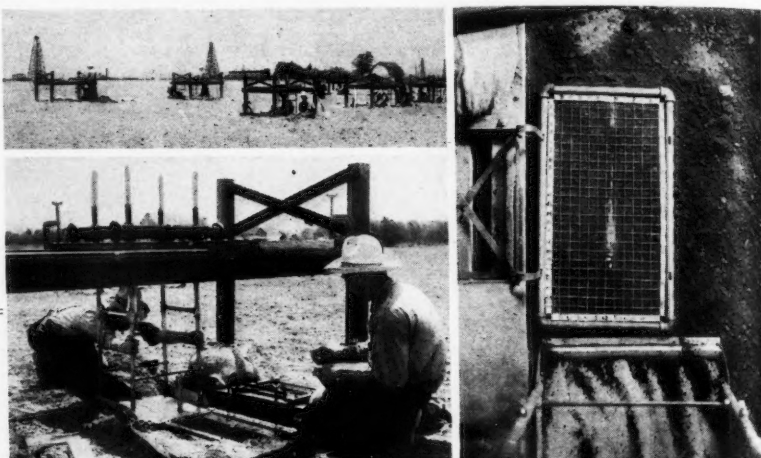


Fig. 1. Fertilizer placement patterns used by the agronomists in the hand-placement tests at the Ohio Agricultural Experiment Station. The seed was planted at a depth of 1.5 in and within a circle of 1.5 in diameter

<sup>1</sup>Paper presented at the 26th annual meeting of the American Society of Agricultural Engineers at Ohio State University, Columbus, June 1932.

<sup>2</sup>Professor of agricultural engineering, Ohio State University, and associate in agricultural engineering, The Ohio Agricultural Experiment Station. Mem. A.S.A.E.

Fig. 2. (Upper Left) Six crews taking fertilizer placement readings in the corn planter tests. Fig. 3. (Lower Left) Close view of one reading unit, showing soil-layer lifting pan and reading frame. Fig. 4. (Right) Looking directly downward onto the reading frame on the plane in which kernels appear



Excepting the 1932 season, four different rates of application have been used each year with each planter, namely, 100, 200, 300, and 400 lb of 4-12-4 fertilizer per acre. The tests have included studies of hill applications only. The record areas have consisted of triplicate plots, each containing at least 25 consecutive hills for each side of each planter; the hills have been 42 in apart each way, and the planters set to drop four-kernel hills.

The relative placement of fertilizer and seed has been determined by the Ohio multiple-plane method, a new system designed by the department of agricultural engineering. Briefly, this method consists of taking off a series of layers of soil, each layer  $\frac{1}{4}$  in thick, and recording what is seen on the top plane of each successive layer; then assembling these plane pictures to show relative placement of fertilizer and seed in the XY, XZ, and YZ planes.

Fig. 2 shows the six crews taking the placement readings during the 1930 planting season. The close-up view, in Fig. 3, of one unit of the special apparatus shows that the soil-layer lifting pan can be moved forward and backward, parallel to the corn row, on a carriage supported by a bridge which arches over two rows. The pan can be lowered by  $\frac{1}{4}$ -in adjustments, and it is so arranged that only the under side of its cutting edge touches the plane about to be exposed. In lifting the soil layer, the pan is

moved forward only as fast as one operator can carefully move the soil back onto the pan with a small pointing trowel.

When a new plane is exposed for reading, the reading frame shown in Fig. 4 is swung into place. This frame consists of a system of coordinates formed of fine wires an inch apart each way. On a field sheet carrying a similar system of marked coordinates, the operators now draw exactly what they see on the soil plane. The reading frame is then swung over out of the way and the soil-layer lifting pan exposes the next plane for a similar reading. As may be noticed in Figs. 3 and 4, the position of the reading frame laterally is held constant throughout the reading of one hill by the gooseneck guides which are fastened to a stationary, reading-frame base.

The six to ten field sheets showing the plane pictures for any one hill are arranged in the order of the depth of the planes. Later in the season these pictures are transferred to a large blue-line print, on the left half of which appear, at one-quarter scale, all of the horizontal plane pictures for that hill. Somewhere in these plane pictures the kernels of corn will show. Using the kernels as the

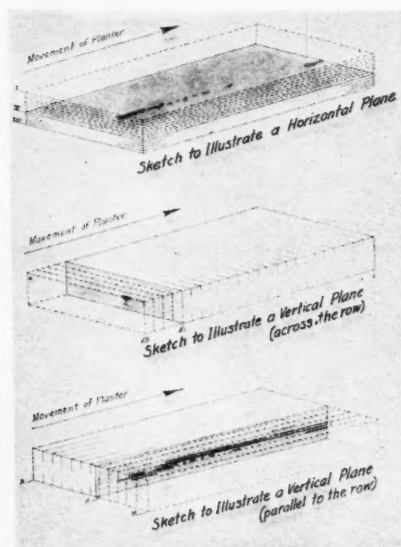


Fig. 5. (Left) Samples of planes in which the studies are made. Fig. 6. (Right) A "composite" of four hills, showing fertilizer and seeds in three planes

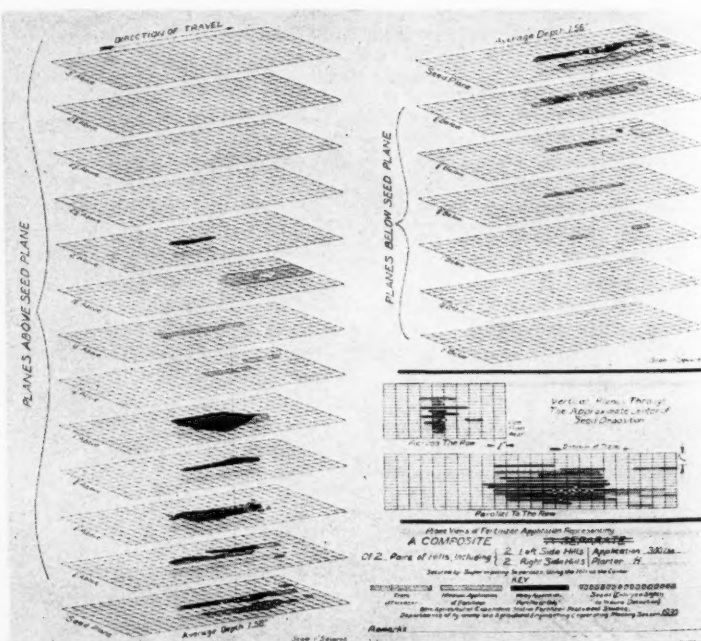


TABLE I. Comparative Performance of Corn Planter Fertilizer Distributors in 1929, 1930, and 1931

Planter	Year	How fertilizer depositor was equipped	Stand Per cent of check				Height Increase over check				Yield Increase over check				Average unfertilized		
			Rate $\frac{lb}{A}$												Stand, per hill	Height, total	Yield, total
			100	200	300	400	100	200	300	400	100	200	300	400			
A	1929	Deflector, no hood.....	Pct. 74.5	Pct. 61.0	Pct. 50.5	Pct. 47.0	In. 19.8	In. 20.9	In. 23.5	In. 19.0	Bu. 5.2	Bu. 0.2	Bu. -8.6	Bu. -13.5	No. 3.54	In. 53.5	Bu. 43.3
	1930	Deflector, no hood.....	98.5	90.9	95.9	92.6	9.0	7.5	5.0	4.5	-2.7	0.8	0.0	-0.9	3.72	26.3	24.0
	1931	Deflector and hood.....	100.0	102.1	87.5	73.0	13.1	22.1	21.2	21.6	16.2	18.0	18.5	13.5	3.49	24.9	35.6
B	1929	No deflector, no hood.....	64.0	67.5	41.5	30.0	15.2	19.4	19.6	20.1	-1.7	-2.3	-18.0	-29.1	3.58	54.5	47.7
	1930	No deflector, no hood (see*)..	91.1	107.9	99.5	101.3	0.0	-0.5	-0.5	1.5	0.4	-2.4	-0.1	-3.7	3.69	25.0	26.4
	1931	Deflector and hood.....	127.4	96.6	87.7	89.6	14.0	25.1	20.2	20.9	11.1	16.9	13.9	21.4	3.52	25.4	36.2
C	1929	Deflector, no hood.....	94.0	86.0	91.5†	88.5	6.2	11.7	12.5	20.3	1.9	5.5	2.7	7.9	3.93	57.3	41.5
	1930	Deflector, no hood.....	97.7	99.1	98.6	87.6	7.5	9.0	6.5	2.0	-0.8	-1.8	-0.2	-0.4	3.75	25.8	25.0
	1931	Deflector and hood.....	103.7	94.3	68.3	75.7	17.8	21.8	20.6	21.2	19.1	18.8	10.2	13.4	3.29	24.8	29.4
D	1929	Deflector and hood.....	92.5	89.0	81.5	71.0	13.6	26.7	21.3	23.9	6.2	12.0	11.4	-0.5	3.47	52.8	37.4
	1930	Deflector and hood.....	65.6‡	81.9‡	90.6	71.1	2.0	10.0	4.5	1.5	-6.8	-2.3	-0.9	-5.2	4.85	28.1	24.8
	1931	Deflector and hood.....	101.0	114.7	94.0	72.8	14.9	20.6	23.8	15.8	15.4	23.5	24.7	4.0	3.37	25.5	34.9
E	1929	\$ O. A. E. S. experimental															
	1930	planter, especially designed	97.7	101.0	91.2	97.5	6.0	10.5	10.5	10.0	2.0	2.7	6.7	1.0	3.66	25.9	23.1
	1931	for band placement	100.0	100.0	98.8	101.0	14.0	20.4	21.0	22.4	11.4	22.7	19.5	20.6	3.50	25.1	36.6

\*At manufacturers' request, planter set in 1930 to place fertilizer about half way between hills.

†Seed valve trouble.

‡Bird injury.

§Not used in 1929.

center of the hill, a series of vertical planes across the row is drawn, each of these vertical planes showing an end view of the horizontal planes along some known line of the original system of coordinates. Likewise, vertical planes parallel to the row are produced, all vertical plane pictures being derived from the original findings of the plane readings taken in the field. In short, the method gives a fairly accurate picture of relative placement of fertilizer and seed in three planes illustrated in Fig. 5.

In addition to receiving the agronomic data on stand, height, and yield for all planters, each manufacturer receives a complete set of large blue-line prints showing how his machine placed the fertilizer and seed in at least two hills for each side of his planter with each of four applications. The manufacturer receives also the agronomists' and agricultural engineers' interpretation of the coordination between machine behavior and field results.

Frequently the performance of a planter varies rather widely between hills in the same test. To picture the limits of such variation, we have resorted occasionally to "composites," a sample of which is shown in Fig. 6. Such a composite is produced by superimposing the horizontal plane pictures for two right-hand hills and for two left-hand hills in the same application test, using the hill as a center. The horizontal planes in Fig. 6, then, show what happened throughout four hills with a certain make of planter in the 300-lb. test. Near the lower right-hand corner of Fig. 6 may be seen the composite of the vertical planes across the row, and also a composite of the vertical planes parallel to the row.

In all of the plane representations the dotted areas indicate traces of fertilizer; the cross-hatched areas indicate medium quantity, and soil-free fertilizer is shown by solid black. Of course, only the top plane of a layer of soil is seen when the field records are taken. When the vertical plane drawings are made, the strips of fertilizer are given sufficient thickness to render them easily visible. Thus the vertical plane pictures are more accurate in showing placement laterally than in showing depth variations within very close limits. It is quite possible to interpolate between adjacent planes, and this is done in some cases.

The plane views in Fig. 6 show that, in this particular test, the planter not only placed the kernels directly in fertilizer, but it also left directly above the seed a heavy column of fertilizer through which the young shoots must pass if the kernels succeeded in sprouting. In the 300-lb application test this planter gave a loss in stand of about 77 per cent in 1929, and about 36 per cent in 1930; its loss in yield, in comparison to the check plots, was about 54 per cent in 1929, and 25 per cent in 1930. A combina-

tion of these agronomic data, the placement pictures, and the theory of proper placement as determined by the hand-placement tests, is indeed an embarrassing compilation for the manufacturer of this machine; and it is very pertinent information for a prospective purchaser of a corn planter.

Fig. 7 shows a type of modern fertilizer depositor. The function of the deflector is to split the fertilizer stream and to deflect one-half the application to each side of the hill. The purpose of the hood is to widen the furrow opened by the corn planter shoe and to hold back the incoming soil until the fertilizer has reached the bottom of the furrow. When a deflector is used without a hood, the incoming soil is quite apt to reunite the two halves of the fertilizer stream and carry the fertilizer back to a position over, or in contact with, the seed.

As a rule, present depositors form four general classes: (1) Those equipped with neither deflectors nor hoods, (2) those equipped with deflectors but no hoods, (3) those equipped with both deflectors and hoods, and (4) specials, such as those equipped with stirring blades.

All planters used in the Ohio tests fall within those four groups, with the exception of the station's experimental planter which will be described later.

To show inferences regarding the effect of design upon stand, height, and yield, pertinent data from five planters for three years are given in Table I. This table indicates also how the depositor of each planter was equipped each year.

The seasons of 1929 and 1931 were both favorable, the rainfall during May and June being near normal or above, and the response to fertilizer in growth and yield satisfactory. The land employed in 1931 was lower in fertility than that of 1929, the unfertilized yields were lower and the response to fertilizers higher. The season of 1930 was highly abnormal, rainfall being markedly deficient and evaporation high throughout the season. Damage to stand for a given machine and rate was in some cases less in 1930 than in the previous year, probably because moisture was so lacking as to inhibit fertilizer movement to the extent that a minimum of separation of seed and fertilizer, either vertical or horizontal, was effective in preventing injury. Fair response in early height was observed, but almost no response in yield. It is believed that the data as a whole can be best interpreted by comparing the results for 1929 and 1931. To facilitate this comparison the data for these years are presented graphically in Fig. 8.

The following remarks on these planters will be of interest. In perusing these statements it is well to keep

\*Reprinted from the Bimonthly Bulletin of the Ohio Agricultural Experiment Station, May-June 1932, No. 156.



in mind that some loss in stand, due to fertilizer application, may be tolerated providing an increase in yield more than compensates for the loss of plants. Also, at the present stage of development of fertilizer depositors, the test work thus far does not show economic justification for applications over 200 lb per acre when all of the fertilizer is applied to the hills of corn spaced 42 in apart.

**Planter A.** In 1929 Planter A placed the fertilizer directly over and about an inch higher than the kernels of corn. The deflector split the fertilizer stream, but, probably resulting from the absence of a hood, the incoming soil reunited the stream, and the covering soil dropped into place before the fertilizer had reached the seed plane. Planting was followed by a rain, which undoubtedly carried some fertilizer salts downward into contact with the seed, and the shoots from kernels which sprouted had to pass through a layer of fertilizer. The result of such placement was a serious loss in stand at all applications and a correspondingly poor showing in yield, with even negative results in yield at the higher applications.

By 1931 the manufacturer of this planter had added a hood to the depositor, and the 1931 stand and yield results seem to indicate, thus far, that the change in design is a decided improvement. It must be remembered, however, that only one year's data are yet available on this new depositor.

**Planter B.** In 1929 this planter carried neither a deflector nor a hood; it placed a little of the fertilizer in contact with the seed at the lighter applications and pulled the balance of the charge ahead of the hill; at the heavier applications it placed more fertilizer in direct contact with the kernels. The detrimental result from such placement are shown in Table I and in Fig. 8.

This planter gave such poor results in 1929 that the manufacturer asked to have the machine set in 1930 to place the fertilizer about half way between the hills in the row. It is interesting to note in Table I that such excessive spacing between hills and fertilizer in 1930 prevented the stand losses of 1929, but the fertilizer was so far from the kernels that it had little if any effect during the early part of the 1930 growing season.

In 1931 the manufacturer of Planter B came into the market with a new depositor equipped with both a deflector and a hood. That this is an improvement is evident in both Table I and Fig. 8, although it must be remembered that this depositor has been used only one season. The yield gains for the 300 and 400-lb applications in 1931 for both Planters A and B are interesting in that the stand losses in those tests were rather high.

**Planter C.** When Planter C was equipped with a deflector only, as in 1929, it dropped the fertilizer a trifle ahead of the seed and drew it out into a long, narrow band. The loss of stand in 1929 is hard to account for, but the height and yield data indicate that the bulk of the fertilizer was somewhat too far from the hills to give good efficiency.

In 1931 the manufacturer offered a new depositor, equipped with deflector and hood, which places a rather narrow band of fertilizer on each side and fairly close to the seed. The stand data for 1931 seem to indicate that the fertilizer may not be too close for the lighter applications, but that some damage results with the higher rates. It will be noticed, however, that the 1931 attachment shows better results than the 1929 device in height and yield; this is due, probably, to the fact that the more modern depositor is placing the fertilizer closer to the hill where it is more efficient during the early growth of the plants.

**Planter D.** This planter has carried a deflector and hood during the three years of testing work, and Fig. 8 indicates that comparative results between 1929 and 1931 are fairly consistent. The depositors of this machine place a band of fertilizer on each side of the hill, with the bands timed well with the kernels. These bands are maintained fairly well at the lighter applications, but, as the quantity of fertilizer is increased to 300 lb per acre, the band formation tends to break, and at 400 lb some fertilizer is in contact with or directly above the seed. The effect of this behavior is evident in the data and bars.

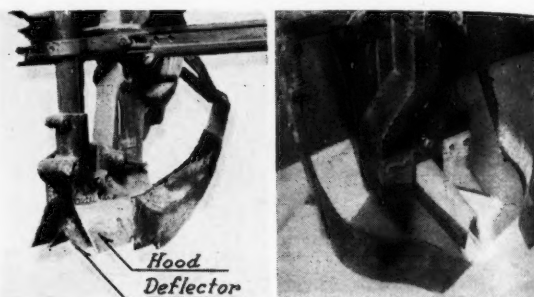


Fig. 7. (Left) A popular type of modern fertilizer depositor. Fig. 9. (Right) One side of the Ohio experimental planter designed for wide-band placement

**Planter E.** This planter is the Ohio Agricultural Experiment Station's experimental job built by R. C. Shipman, an advanced student in agricultural engineering. It is an attempt to secure mechanically two fertilizer bands per hill, each band being fully 2 in wide and 7 in long, and the bands spaced 3 in apart equidistant from the seed. As indicated in Fig. 9, this machine carries very special equipment. Each boot contains two fertilizer valves, each 2 in wide, and the fertilizer stream is split before the material reaches the valves. Each boot opens a furrow 7 in wide, so that ample space is allowed laterally for two 2-in bands fully 3 in apart. To prevent incoming soil from disturbing the fertilizer bands, each depositor is so arranged that all covering soil for the fertilizer drops downward into place instead of moving in from the sides, and the seeds are protected until the fertilizer bands have been partially covered.

Although the experimenters did not succeed in securing perfectly shaped bands with Planter E, nevertheless wide-band formation, with the bands well separated, has been more closely approximated with this machine than with any of the commercial jobs. As an average of all applications, Planter E gave better results than any other planter in the 1930 tests. How it behaved in comparison to four other planters in 1931 can be seen in Fig. 8. That it places fertilizer safely, from the standpoint of germination, is evident from the stand data. At the lighter applications, the fertilizer may be a little too far from the seed to give best efficiency, but it should be noted that at the higher rates of application both the height and yield results show favorably, with no loss in stand.

The Ohio experimental planter was not built as a pattern for commercial adaptation in its entirety, but manufacturers have copied from it some points which have practical possibilities.

It may be inferred from the previous, brief description of the performance of four common makes of corn planters that considerable progress is being made in the design of fertilizer depositors for spot applications. Since the test work started in 1929 three prominent manufacturers have made material changes in design which the test work thus far can brand as marked improvements. Obviously these manufacturers and the corn growers of the state are the beneficiaries.

The planter manufacturers are to be commended not only for their interest in and loyal support of the test work, but also for the sincere effort which most of them have put forth to improve the design of depositing mechanisms.

It is not to be inferred, however, that the problem of relative placement of fertilizer and seed is solved. Fertilizer depositor design which embodies the deflector and hood combination seems to perform best; yet in 1931 two planters not so equipped gave results so contrary to expectations that the field work has had to continue at least one more year.

Many peculiar things have come to the surface, and there are many perplexing questions yet to be answered.

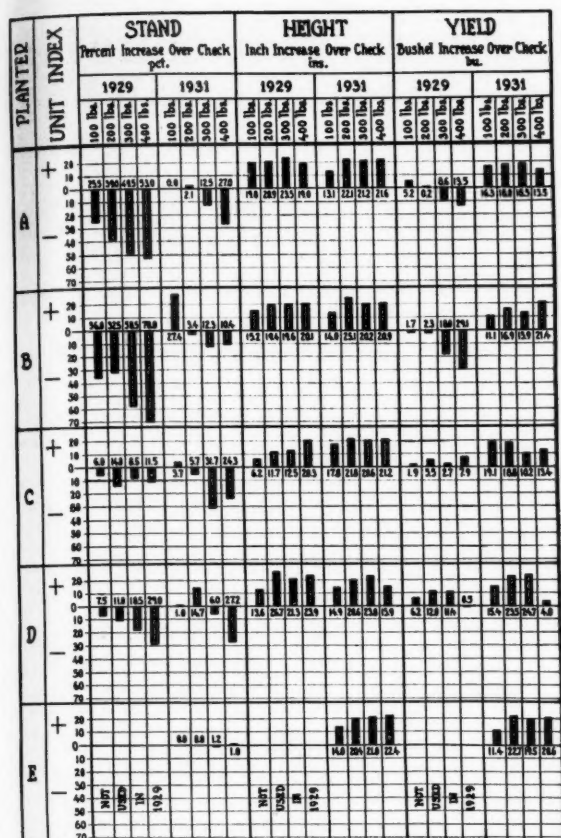


Fig. 8. Graphic presentation of some relationships in Table I, indicating progress in the design of fertilizer depositors (From O.A.E.S. Bimonthly No. 156)

While the botanists are struggling with fundamental relationships between root morphology and fertilizer salts, and while the agronomists are studying the behavior of fertilizers under a variety of soil conditions, the agricultural engineers must find out more about what goes on within and just under a fertilizer depositor. A detailed study of

all placement readings taken to date indicates that there are some fundamentals not yet known about the behavior of incoming soil in respect to the seed and in respect to the depositing mechanism. As soon as time and funds permit, the Ohio station proposes to tackle this problem through true research approach in an attempt to establish some principles which may have great value as the basis for design.

Even if drilling corn increases in popularity with the advent of the multiple-row, tractor planter, we still have the problem of relative placement of fertilizer and seed, although a continuous flow of fertilizer does not offer quite the problem that spot application presents. There may be some advantage, however, in spot applications at each kernel in drilled corn. Some of us who are involved in the complexities of fertilizer placement problems, and who dare to predict, are inclined to believe that ultimately the fertilizer mechanism will be an integral part of the planting mechanism instead of being simply an attachment. If this is true, then the tractor-planter designer must take the fertilizer mechanism into consideration as quickly as he does the seed boot.

Mr. G. A. Cumings, of the U.S.D.A. Bureau of Agricultural Engineering, Prof. R. M. Salter, and the author of this paper, form a committee on machine application as a subcommittee of the national joint Committee on Fertilizer Application. Realizing that the manufacturers should have the advantage of placement readings and agronomic data from a variety of soil and climatic conditions, the subcommittee this last spring recommended that Michigan, Indiana, Minnesota, Wisconsin, Illinois, Iowa, and Missouri start work similar to the Ohio planter tests. On account of the financial situation, not many of these states have been able to start in 1932, but the recommendations were cordially received, and it is hoped that the placement test work can be expanded, not only in its field-test phases, but also from the standpoint of basic research applied to placement with both corn and potatoes. The Ohio multiple-plane method of determining placement of fertilizer has been used with considerable success by the Ohio station in potato work.

There is some evidence that, in spite of the rather extensive placement studies already made, the agricultural experiment stations are not developing the theory and practice of placement as rapidly as the designer can use the information. This is especially true of power planter design, which in the next few years may see changes that seem more revolutionary than evolutionary. Will the designer be forced to cut-and-try and take-a-chance, or can the agricultural engineers in the experiment stations, in cooperative projects with the agronomists, "come through" in time to definitely point the way?

## Stationary Spray Plants Satisfactory

Editor, AGRICULTURAL ENGINEERING

Our office has recently received an inquiry from New York, where it appears that someone selling portable spray plants made a statement that the stationary spray plant development in the state of Washington had not proved as satisfactory as anticipated, and that there was a tendency to go back to the portable outfits. The following letter from our county agent in the great Wenatchee apple-growing district, where from 15 to 20 thousand carloads of apples are shipped out every year, will possibly be of interest.

L. J. SMITH.

Agricultural engineer  
State College of Washington  
March 23, 1932

Dear Professor Smith:

... I have been in this county nearly seven years, and do not know of one man who has reverted back to the portable sprayer after using the stationary. About two thirds of the outfits in north central Washington are now stationary sprayers, and the rest of the farmers are going to get them just as soon as they can get money

enough to install them. Of all orchard practices ever introduced into this fruit district, this is the one practice which meets with 100 per cent approval. The stationary sprayer saves expense and time. It is economical in every respect. It eliminates the necessity of horses or tractors on many orchards. It makes possible the spraying of steep hillsides with greater efficiency, prevent baking of soil, destruction of irrigation ditches, and facilitates late sprays, where it would be impossible to get through with portables. It makes possible the installation of large tanks and less stops for filling. In fact, stationary spraying has been the most revolutionary improvement of orchard methods that has ever been adopted in the fruit industry. I am constantly getting inquiries concerning the use of the stationary sprayer from practically every fruit district of the United States, and I assumed that other orchard districts were beginning to adopt this method.

A. R. CHASE

County agricultural agent  
Chelan County, Washington  
March 1, 1932

# How to Determine the Quantity of Air and Air Horsepower Delivered by a Hammer Mill Fan<sup>1</sup>

By John E. Nicholas<sup>2</sup>

FOR steady motion of a fluid along a pipe in one dimension the dynamical equation is

$$\frac{du}{dt} = u \frac{du}{ds} = \frac{-g}{\rho} \frac{dp}{ds} + X \quad [1]$$

The variables used to characterize the motion are the position  $s$  along the pipe and the time  $t$ . The velocity  $u$  along the pipe, the pressure  $p$  in the fluid, and the density  $\rho$  depend on  $s$  and  $t$ .

$X$  is an acceleration of the external applied force. The external acceleration is that due to gravity, namely,  $X = -g$ .

Transposing Equation 1 we have

$$u du + g \frac{dp}{\rho} - X ds = 0$$

which when integrated gives

$$\int_{u_0}^u u du + \int_{p_0}^p g \frac{dp}{\rho} - \int_{s_0}^s X ds = 0$$

$$\frac{u^2 - u_0^2}{2g} + \int_{p_0}^p \frac{dp}{\rho} - \frac{1}{g} \int_{s_0}^s X ds = 0$$

or

$$\frac{u^2 - u_0^2}{2g} + \frac{p - p_0}{\rho} - \frac{X}{g} (s - s_0) = 0 \quad [2]$$

This is known as Bernoulli's equation, and for a liquid under gravity may be written

$$\frac{u^2}{2g} + \frac{p}{\rho} + h = C \quad [3]$$

The height  $h$  represents the static "head" above a certain level. The term  $u^2/2g$  is called the kinetic head, and  $p/\rho$  the pressure head. Formula 3 states that the total head—kinetic plus pressure plus static—must be constant in steady motion.

**The Pitot Tube.** The Pitot tube is a device for measuring velocity in a stream of air. The tube is double, the inner tube being exposed directly to the flow of the air. The outer tube has small perforations which transmit the pressure of the air in the moving stream. In both tubes the air is necessarily at rest. The inner tube transmits the pressure of the air at the nozzle, where the stream is stopped and the velocity is zero. The outer tube, through its lateral openings, transmits the pressure in the stream when in motion. By Bernoulli's proposition, the pressure where the stream is in motion and the pressure where the stream has been brought to rest differ by an amount proportional to the velocity. The velocity in the stream, therefore, may be taken as

$$u^2 = \frac{2g(p_0 - p)}{\rho} \quad [4]$$

Here  $(p_0 - p)$  is the pressure difference, as measured by the Pitot tube, in pounds per square foot,  $\rho$  is the density of the air in pounds per cubic foot and  $u$  is the velocity in feet per second.

The velocity of flow for air in a pipe is more generally expressed from Equation 4 as

$$u = \sqrt{2gh} \quad [5]$$

in which the factor  $h = (p_0 - p)/\rho$  is expressed in feet, and represents the vertical distance through which a falling body acquires a velocity of  $u$  feet per second. For a fluid such as air the factor  $h$  is called the velocity pressure and must be expressed in feet head of the fluid flowing.

**Fans.** The hammer type grain grinding mills are equipped with fans. The function of the fan is to remove the ground grain from the hopper of the mill, and deliver it through pipes or tubes to a storage at some higher elevation. The quantity of air required depends upon the capacity of the mill, while the velocity of this air is determined by the speed, blade area, and diameter of fan. A

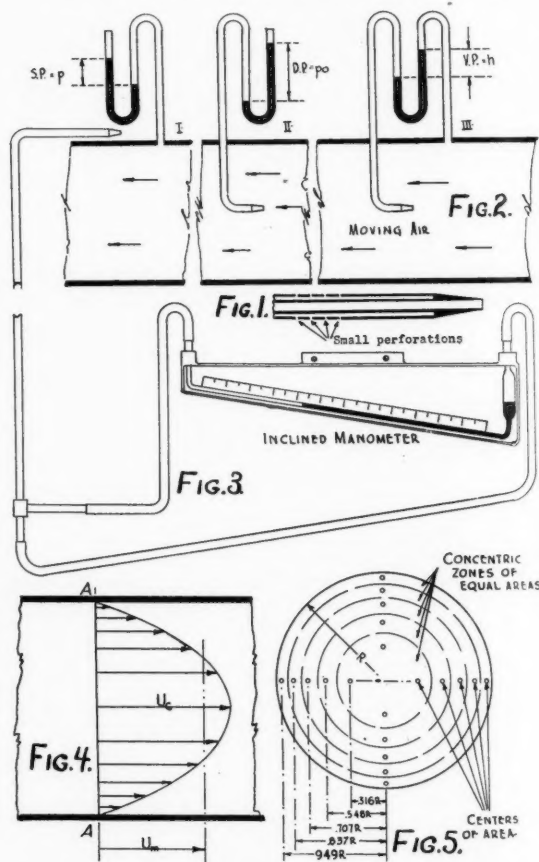


Fig. 1. Pitot tube. Fig. 2. Air pressure measurements (greater than atmospheric). Fig. 3. Schematic arrangement for measuring velocity pressure direct by the Pitot tube. Fig. 4. Velocity vectors at section A-A. Fig. 5. Locations of Pitot tube

<sup>1</sup>Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 554.

<sup>2</sup>Associate professor of agricultural engineering, The Pennsylvania State College. Mem. A.S.A.E.



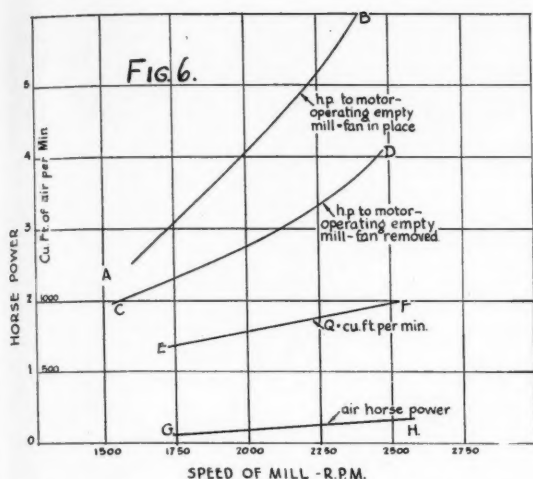


Fig. 6. Curves showing power requirements of hammer mill without load and operated by a 5-hp motor

very definite relation should exist between the quantity of air the hammer mill fan delivers and the capacity of the fan, because on this relation depends the overall efficiency of the unit.

**Fan Pressure.** Fans in operation create pressures less than atmospheric on their suction side, and produce pressures greater than atmospheric on the discharge side. Only the latter case will be considered.

A fan delivering air maintains a total pressure which is made of two components, velocity pressure,  $h$ , and static pressure,  $p$ . The velocity pressure is utilized in maintaining the velocity of air flow. The static pressure is utilized in overcoming frictional and other resistances offered to the flow of air. It is the pressure that tends to burst the pipe.

Fig. 2 illustrates a part of a duct of circular section in which air is flowing at some velocity with a static pressure (S.P. =  $p$ ) greater than that of the outside air. The static pressure existing within the pipe at any point may be obtained at that point by attaching a low-reading pressure gage or manometer to a connection made at right angles to the longitudinal axis of the duct, as at I in Fig. 2.

The velocity pressure is obtained by the determination of the dynamic pressure (D.P. =  $p_d$ ) and subtracting from it, either mathematically or by the proper attachment, of the static and dynamic pressure connections to the measuring gages. The method of obtaining the dynamic pressure is shown at II in Fig. 2. A piece of tubing of small internal diameter and thin walls is bent at right angles and has the end of the short leg cut squarely across and the tube walls ground to a thin edge. The tube is inserted into the duct with the short bent portion located parallel to the longitudinal axis of the duct, so that the moving air will flow directly against the open end of the tube. When the outer end of the tube is attached to a manometer the impact of the air as well as the static pressure at that

Table I.  
Speed of fan, 1740 rpm

Pitot tube station	Pressure in Inches of Water			$\sqrt{V.P.}$
	(D.P.) dynamic	(S.P.) static	(V.P.) velocity	
1	0.895	0.295	0.600	0.7746
2	1.095	0.295	0.800	0.8944
3	1.215	0.295	0.920	0.9592
4	1.225	0.305	0.920	0.9592
5	1.175	0.315	0.860	0.9274
6	0.815	0.305	0.510	0.7141
Average	1.070			0.871

particular location are indicated. The velocity pressure may be obtained directly if the dynamic and static pressure attachments are made to a single gage at III in Fig. 2.

A commercial type of Pitot tube, adopted by the American Society of Heating and Ventilating Engineers, combines in a single instrument both static and dynamic pressure openings. Fig. 3 shows the schematic arrangement in measuring the velocity pressure (V.P. =  $h$ ) in inches of water direct by the Pitot tube.

**Quantity of Air Flowing.** The quantity of fluid flowing in any duct is equal to the product of the duct section in square feet and the mean velocity of flow at that section.

$$Q = A U_m \quad [6]$$

in which

$Q$  = cubic feet flowing per second

$A$  = duct cross-section area in square feet

$U_m$  = mean velocity of flow in feet per second.

If at any section, as A-A<sub>1</sub> of the duct, Fig. 4, the velocity vector,  $U_c$ , represents the velocity at the center of the duct, the velocity vector of the particles at the surface of the duct will be zero, that is, the velocity of flow is not uniform over a duct cross-section so that several velocity-pressure determinations are required to secure the mean velocity of flow existing at any Pitot tube station. The duct cross-section is generally divided into a number of concentric zones of equal areas, and velocity pressure observations are made with the Pitot tube properly located within these areas. A scheme of locating the Pitot tube at various stations on two diameters of a circular duct cross-section is shown in Fig. 5.

If  $n$  represents the number of concentric zones of equal areas into which the duct is divided, and  $A_1, A_2, A_3, \dots, A_n$ , the area in square feet of Zones 1, 2, 3,  $\dots$ ,  $n$ , and  $U_1, U_2, U_3, \dots, U_n$  the velocity of the air in feet per second flowing in the respective zones, then the quantity of air flowing through Zones 1, 2, 3,  $\dots$ ,  $n$  will be

$$Q_1 = A U_1$$

$$Q_2 = A U_2$$

$$Q_3 = A U_3$$

$$Q_n = A U_n$$

Since the total quantity of air flowing through the duct must be equal to the sum of the quantities of air flowing through each zone, then

$$Q = (Q_1 + Q_2 + Q_3 + \dots + Q_n)$$

or

Table II. Dynamic and Velocity Pressures at Higher Speeds of the Fan

Pitot tube stations	Speed of fan								
	2065 rpm			2250 rpm			2495 rpm		
	D. P.	V. P.	$\sqrt{V. P.}$	D. P.	V. P.	$\sqrt{V. P.}$	D. P.	V. P.	$\sqrt{V. P.}$
1	1.18	0.84	0.9165	1.495	0.89	0.9434	1.850	1.250	1.1180
2	1.68	1.19	1.0908	1.825	1.31	1.1446	2.305	1.705	1.3058
3	1.78	1.30	1.1402	2.035	1.51	1.2288	2.455	1.850	1.3662
4	1.79	1.28	1.1314	2.045	1.50	1.2247	2.515	1.890	1.3748
5	1.79	1.18	1.0863	1.955	1.40	1.1832	2.450	1.815	1.3472
6	1.32	0.73	0.8544	1.455	0.87	0.9327	1.725	1.050	1.0247
Average	1.590		1.0366	1.801		1.093	2.2167		1.246

$$Q = \Sigma (A_1 U_1 + A_2 U_2 + A_3 U_3 + \dots A_n U_n) \quad [7]$$

From Equation 5,  $U = \sqrt{2gh}$ , and  $h$  is the velocity pressure expressed in feet head of the fluid flowing. The velocity pressure (V.P.) as obtained by the Pitot tube is usually measured in inches of water. Then

$$h = \frac{\delta(V.P.)}{12\rho}$$

in which

$h$  = head of the fluid flowing

V.P. = velocity pressure measured by the Pitot tube, inches of water

$\delta$  = density of the water (weight of 1 cu ft)

$\rho$  = density of the fluid flowing, pounds per cu ft.

Substituting the value of  $h$  in Equation 5 we have

$$U = \sqrt{2g} \sqrt{\frac{\delta(V.P.)}{12\rho}}$$

If  $(V.P.)_1, (V.P.)_2, (V.P.)_3, \dots (V.P.)_n$  are the velocity pressures as obtained by the Pitot tube at the respective stations, then

$$U_1 = \sqrt{2g} \sqrt{\frac{\delta(V.P.)_1}{12\rho}}$$

$$U_2 = \sqrt{2g} \sqrt{\frac{\delta(V.P.)_2}{12\rho}}$$

$$U_n = \sqrt{2g} \sqrt{\frac{\delta(V.P.)_n}{12\rho}}$$

Substituting these values in Equation 7 we get

$$Q = \Sigma \left[ A_1 \sqrt{2g} \sqrt{\frac{\delta(V.P.)_1}{12\rho}} + A_2 \sqrt{2g} \sqrt{\frac{\delta(V.P.)_2}{12\rho}} + \dots A_n \sqrt{2g} \sqrt{\frac{\delta(V.P.)_n}{12\rho}} \right] \quad [8]$$

But  $A_1 = A_2 = \dots A_n = S$ , where  $S$  represents the area of one zone, and  $n$  equals number of zones. Then  $A = nS$ , the total area of the pipe.

Substituting in Equation 8 we have

$$Q = A \sqrt{2g} \sqrt{\frac{\delta}{12\rho}} \Sigma \left[ \frac{\sqrt{(V.P.)_1} + \sqrt{(V.P.)_2} + \dots + \sqrt{(V.P.)_n}}{n} \right]$$

**Fan Air Horsepower.** The horsepower output of the fan represents the rate at which work is done by the fan.

$$\text{Air horsepower (ahp)} = \frac{W \times H}{33000} \quad [9]$$

$W$  = pounds of air delivered by the fan per minute

$H$  = Total or dynamic head against which the fan operates, feet head of air.

$$\text{but } H = \frac{(D.P.) \times \delta}{12\rho}$$

**Table III. Mean Velocity (Cubic Feet of Air and Air Horsepower from Tests of Table II)**

Fan speed	1740 rpm	2065 rpm	2250 rpm	2495 rpm
Mean velocity, fps ( $U_m$ )	58.1	69.16	72.93	83.13
Cu ft of air per min (60Q)	690.0	815.00	858.00	980.00
Air horsepower (ahp)	0.116	0.203	0.242	0.341

Where  $(D.P.)$  = the dynamic or total head exerted by the fan, in inches of water, and  $W = Q \times \rho \times 60$

Hence

$$\text{Air horsepower (ahp)} = \frac{Q \times 60 \times (D.P.) \times \delta}{12 \times 33,000} \quad [10]$$

**Application of Theory.** The following data were obtained on the 15-in diameter, four-bladed fan operating a commercial hammer mill. The diameter of delivery pipe, in which the Pitot tube measurements were made, was 6 in, making the cross-sectional area  $A = 0.1964$  sq ft.

The density of the air, at 70 deg (Fahrenheit) with the barometer reading 29.20 in (of mercury), is = 0.0748 lb per cu ft, and  $\delta = 62.3$  lb per cu ft.

$$\text{Since } U_m = \sqrt{2g} \sqrt{\frac{\delta}{12\rho}}$$

$$\Sigma \left[ \frac{\sqrt{(V.P.)_1} + \sqrt{(V.P.)_2} + \dots + \sqrt{(V.P.)_n}}{n} \right]$$

$$U_m = \sqrt{2 \times 32.16 \times \frac{62.3}{12 \times 0.0748}} \times 0.871^* = 58.1 \text{ fps}$$

and  $Q = AU_m = 0.1964 \times 58.1 = 11.51$  cfs

Substituting in Equation 10

$$\text{Airhorsepower} = \frac{11.51 \times 60 \times 1.07 \times 62.3}{12 \times 33,000} = 0.116 \text{ ahp}$$

Results of additional tests at higher speeds of the fan are shown in Table II.

The results on power requirements for the hammer mill under consideration, when running without any load and operated by a 5-hp motor, are plotted in Fig. 6.

Curve AB shows the power necessary to operate the mill at various speeds without any applied load. Curve CD shows the power required when the fan was removed, all other conditions remaining the same. Curves EF and GH show the quantity of air, in cubic feet per minute and air horsepower, respectively, at the corresponding speeds of the fan, in revolutions per minute.

The recommended speed of operation for this mill is 2250 rpm. At this speed it takes 1.85 hp to run the fan, while the air horsepower developed is only 0.242, making it 13 per cent efficient.

Table III shows that the mean velocity of the air is 58.1 fps at 1750 rpm, and 83.1 fps at 2495 rpm. This is equivalent to 39.5 and 57.0 mph. This excessive speed is wasteful both from the standpoint of power required to produce this velocity and the waste in ground grain, especially the fine particles which are carried along by the air through the dust collector.

Curve AB shows that the power necessary to operate the mill without any load is equally excessive.

The condition is particularly hazardous when the recommendations are made that the mill can be operated by a 5-hp motor, because any small amount of useful load will at once exceed the rating of the motor.

\*The average of the square roots of the velocity pressures. See last column Table I.

# Farmstead Arrangement and Its Effect on Operating Costs<sup>1</sup>

By H. B. White<sup>2</sup>

THE PART of the farm laid out for the building site and including the yards, gardens, grove, orchard, and driveways is called the farmstead. It is asked frequently "What is the proper arrangement of buildings in a farmstead to make it most efficient?" The first analysis of this problem leads one to the conclusion that the fewer structures there are, the more economical the labor and the lower the shelter cost. As this is not followed in common practice in Minnesota, it was deemed advisable to study a number of farmsteads where the farm business is being carried on under improved farm management methods. The division of agricultural economics and Farm Management of the University furnished a list of five beef and five dairy farms where the farm business had been studied and where the farmers were efficient in their use of labor.

These farmsteads were carefully measured and mapped and fifteen chore routes measured on each. The five beef farmsteads varied from 3.96 to 8.77 a with an average of 6.30 a. Dairy farmsteads varied from 2.13 to 6.58 a with an average of 3.87 a. Routes were measured from door to door of the different buildings, with a measuring wheel.

The lengths of the routes varied considerably, influenced by the size of the farmstead, the slope of the ground and the individual ideas of the owner. Table I shows the areas of the farmsteads, the lengths in feet of the various routes, the average route length for each farmstead, the average length of each type of route for all the farmsteads, the average for the five beef, the average for five dairy, and the average routes for all ten farmsteads.

In order to bring out the length of routes for comparison Table II shows the low route in each case, the average of the five beef farmsteads, the average for the five dairy farmsteads, and the average for all ten farmsteads.

Distances on an individual farmstead may not mean very much but the averages show a trend in farmstead arrangement for the section studied. Table III shows

routes on Farmstead Plan No. 319, which has been used by many farmers in studying their building sites to locate new buildings. The table shows approximate routes on 4, 5 and 6-a farmsteads. It is not likely that the routes would change with the increase of size quite as much as Table III indicates, as usually the yards and groves increase more than the distance between buildings.

Owing to differences in equipment and methods of caring for animals there is considerable variation in the number of trips made from building to building. If one trip each day to and from each building were taken as an average there is for the average farmstead a total distance of fifteen trips of twice 138 ft which equals 4,140 ft per day. If as in Farmstead Plan No 319 the distance can be reduced to 108 ft the total distance will be 3240 ft, a saving of 900 ft per day. Every 14.4 ft traveled each day totals a mile in a year. The 900 divided by 14.4 equals 62.5, the number of miles saved per year. At 3 mph this would require 20.8 hr, or two days of walking per year.

A study of the essentials of a good farmstead shows that the following points should be considered:

1. Ease of access to the fields and pastures, nearness to the public road. Usually this locates the farmstead near the middle of one side of the farm.
2. Good drainage around the buildings. This will prevent the water from rain and melting snow from collecting and making the yards and roads almost impassable.
3. Suitable size. The size should be suited to the farm and should be based on the kind of farming and anticipated future development of the business.
4. Convenient arrangement of the buildings so that the work of feeding stock, etc., can be done without extra travel.
5. Proper distance of other buildings from the house so that odors, flies, and noises will not be objectionable and danger from fire will not be serious; and yet not so far that time will be wasted by unnecessarily long chore routes.
6. Proper distance of buildings from road to avoid dust and danger from passing automobiles.
7. Proper location of trees, shrubs, and garden. Trees

Table I. Chore Routes of Farmsteads  
(Route lengths given in feet)

Farmstead	Area (acres)	House to					Barn to				Poultry to			Hogs to		Corn-crib to	Average length of route
		Barn 1-2	Poultry House 1-3	Hog House 1-4	Corn Crib 1-5	Granary 1-6	Poultry House 2-3	Hog House 2-4	Corn Crib 2-5	Granary 2-6	Hog House 3-4	Corn Crib 3-5	Granary 3-6	Corn Crib 4-5	Granary 4-6	Granary 5-6	
Beef																	
1	6.82	140	135	190	190	184	92	220	220	207	300	300	283	54	42	85	176
2	8.77	205	100	290	220	310	120	110	60	120	270	200	280	20	100	90	166
3	3.96	228	100	242	170	167	40	90	70	90	150	86	86	48	48	0	108
4	6.95	282	105	328	243	243	250	54	90	90	280	225	225	60	60	0	170
5	5.01	160	71	145	90	242	100	170	120	102	130	120	196	56	260	230	146
Average	6.30	203	102	239	183	220	120	129	112	124	226	186	214	49	104	81	153
Dairy																	
6	4.98	165	126	224	188	109	111	90	125	96	186	201	25	58	17	124	123
7	2.13	123	91	290	94	143	108	109	120	172	266	13	68	279	333	54	151
8	6.58	110	102	262	160	129	95	113	85	69	191	169	150	108	144	46	129
9	3.31	132	99	192	202	63	64	0	86	94	100	159	57	178	94	171	113
10	2.36	123	133	142	92	109	103	54	39	116	154	119	53	34	115	78	98
Average	3.87	131	110	222	149	111	96	73	91	109	179	132	71	131	141	95	123
Average of ten	5.08	167	106	230	166	170	108	101	102	116	203	159	142	90	122	88	138

<sup>1</sup>Paper presented at the Structures Division session of the 26th annual meeting of the American Society of Agricultural Engineers, at Ohio State University, Columbus, June 1932.

<sup>2</sup>In charge of farm structures section, Division of Agricultural Engineering, University of Minnesota. Mem. A.S.A.E.



Table II. Farmstead Chore Routes  
(Route lengths given in feet)

Route	Low route	Average of five beef	Average of five dairy	Average of ten
House to barn	110	203	130	167
House to poultry house	71	102	110	106
House to hog house	142	239	222	230
House to corn crib	90	183	149	166
House to granary	63	229	111	170
Barn to poultry house	40	120	96	108
Barn to hog house	0	129	73	101
Barn to corn crib	39	112	91	102
Barn to granary	69	124	109	116
Poultry house to hog house	100	226	179	203
Poultry house to corn crib	13	186	132	159
Poultry house to granary	25	214	71	142
Hog house to corn crib	20	49	131	90
Hog house to granary	17	104	141	122
Corn crib to granary	0	81	95	88
Average route		153	123	138

for the windbreak should be in the direction of the prevailing winds in winter. This is usually north and west. Shrubs should be located to improve the appearance. The garden and orchard should be near enough for the vegetables and fruits to be cared for and gathered without unnecessary travel.

8. Convenient driveways add much to the satisfaction derived from a well laid out farmstead.

9. Attractiveness of view from house. It is well to con-

Table III. Farmstead Chore Routes, Plan No. 319

	Four acres	Five acres	Six acres
	ft	ft	ft
House to barn	115	128	140
House to poultry house	106	119	130
House to hog house	194	217	238
House to corn crib	150	168	184
House to granary	150	168	184
Barn to poultry house	97	108	119
Barn to hog house	150	168	184
Barn to corn crib	88	99	108
Barn to granary	88	99	108
Poultry house to hog house	97	108	119
Poultry house to corn crib	49	55	61
Poultry house to granary	49	55	61
Hog house to corn crib	53	59	65
Hog house to granary	53	59	65
Corn crib to granary	0	0	0
Average route	96	108	118

sider this point carefully when locating windbreaks, shrubs, etc., as a view toward the road, the village, or a lake adds to the enjoyment of life. The view from the kitchen windows should be carefully considered, as much time is spent in the kitchen of a farmhouse.

10. Attractive appearance from the public road has much to do with the value of a farmstead and the satisfaction derived from it. The house should have the most carefully selected site and the barns and other buildings should be somewhat in the background.

## Influence of Ionized Air on Day Old Chicks<sup>1</sup>

**D**URING my laboratory experiments from 1922 to 1930, I secured very favorable results showing the influence of air and gas ionization on animals. From my experimental observations on animals as well as humans, I discovered that "ionized" air stimulates organisms to higher activity and increases simultaneously various productions by organisms, has some prophylactic influence, protecting organisms from infection and disease, and also has some therapeutic action.

On February 16, 1931, experiments with day-old chicks were started at "Arjenka," a Soviet poultry farm (Sovhoz) located in the Central Chernozem Region near Voroneg. Of 1000 chicks selected, 500 were put in the control group, and 500 were subjected to ionization. From each of these groups 100 were selected for methodical individual research as to influence of ionization upon growth. Those selected for the experimental and control groups were of identical weights. They were placed in four divisions: Group A weighing 25 grams each, Group B 35 grams, Group C 38 grams, and Group D 42 grams. Each group was kept in a separate brooder house. The ionization was gradual, starting at 15 min per day, and ending at about 2 hr. Due to some difficulty with the electrical apparatus, for several days no ionization took place. Chicks were marked with colored leg bands. Rations, temperature, light, and all other conditions were identical for both groups. Weights were taken every five days of each experimental and control bird. All of the 500 chicks were observed as to disease and general losses.

The following is the summary of the observations:

1. Average gains in weight of those "ionized" were 24 per cent higher than those of the control (natural) group.
2. Effectiveness of ionization was particularly marked in weak chicks.
3. Ionized chicks show progressive increase in weight; in control chicks the increase is much slower.

<sup>1</sup>Abstract of an article by A. L. Chljevsky originally published in "Soviet Poultry Husbandry," and in "Electrification of Agriculture," Agricultural Collective Press, Commissariat of Agriculture, U.S.S.R. Translated from the Russian by J. W. Pincus, Assoc. Mem. A.S.A.E., who states that similar experiments are being continued by the Poultry Institute of the Leningrad Agricultural Academy, under the general supervision of Prof. Chljevsky.

4. Average growth of ionized chicks is about 35 per cent greater than in others.

5. Maximum weights of individual chicks at the fifth weighing were found to be as follows:

Group	Ionized Chicks	Control Chicks	Difference
1	160	150	10
2	200	185	15
3	210	170	40
4	205	175	30

6. Total loss from 500 control chicks, 91; total loss from 500 ionized chicks, 38, or 139 per cent more with the control group than with the ionized.

7. As to diseases of "Vitaminose," 81 per cent less is found in ionized birds. Of 250 ionized, 16 had it; and of 250 control birds, 29 had it. In the control group there was a larger number of chicks which showed slight symptoms of this disease.

8. While all control chicks had diarrhoea (not contagious bacillary), only 10 per cent of those ionized had it.

9. General liveliness and livability is several times greater in ionized chicks.

All the above figures and observations prove beyond any doubt that ionization of air has a great biological effectiveness.

No record of the cost of electricity has been kept, but as very little current is needed to operate the apparatus for ionization, there is no question that the adaptation of this process on a large scale would be profitable.

The experiments will be continued. Following are some of the problems which we shall study:

1. Influence of unipolar ionization of positive and negative
2. Influence of gas and air bipolar (light and heavy) ions
3. Influence of gas ions of different doses upon incubation
4. Influence upon histology of embryos
5. Growth and weight of chicks in the course of several months
6. Egg-laying
7. Influence of ionization on adult birds—meat, progeny, all kinds of chronic and epidemic diseases, as well as all other problems related to commercial poultry husbandry.

# Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

**A Progress Report of Investigations of the Various Uses of Electricity on the Farms of Washington for the Year 1931.** L. J. Smith and H. L. Garver ([Pullman]: Washington Committee on the Relation of Electricity to Agriculture, 1932, pp. 33, pls. 12).—This is the seventh annual progress report of the Washington Committee on the Relation of Electricity to Agriculture. It contains data from studies of the influence of ultra-violet light on milk production, on the use of carbon lamp brooders, grain elevating, irrigation of orchards by sprinkling, evaporation, apple washing, and soil heating.

The tests on irradiation of cows and of cow feed did not show any effect either in weight changes or in the general appearance of the cow. The results indicate that the irradiation of the feed offers the most promise. In the grain elevating tests it was found that the power requirements of the pneumatic type of elevator were not excessive. While the power required for the blower was more than twice that required for the cup or drag type of elevator when handling the same amount of grain, the actual cost of electricity was but a small percentage of the total cost of handling the grain. The results of observations over two seasons of orchard irrigation with sprinklers indicated that the greatest problem connected with their operation is the elimination of floating trash. It was found that particles heavier than water will settle out quite readily if sufficient settling box space is provided. The most trouble is caused by woody materials impregnated with sand or mud which have about the same specific gravity as water.

Tests of the evaporation from orchard irrigation sprinklers showed that there is no close correlation between any of the factors influencing evaporation taking place. There was no more loss from sprinklers which broke the water into a fine spray than from those which spread it in large drops.

**Investigation of Loads on Three Cast Iron Pipe Culverts Under Rock Fills.** M. G. Spangler (Iowa Engineering Experiment Station (Ames) Bulletin 104 (1931), pp. 37, figs. 12).—Results of studies are reported from which conclusive proof was obtained that the rock fills investigated acted in a manner analogous to an earth fill. Evidence is presented to show that the load on a culvert is not a direct function of the height of the embankment, but that the relative settlements of the culvert and various horizontal planes of the embankment must be taken into account if the loads are to be determined. It was found that maximum loads do not develop until a considerable time has elapsed after the embankment has been placed.

**Farm Power in the Yazoo-Mississippi Delta.** L. E. Long (Mississippi Station (A and M College) Bulletin 295 (1931), pp. 30, figs. 10).—This bulletin reports the results of a study conducted in cooperation with the U.S.D.A. Bureau of Agricultural Economics, Animal Industry, and Agricultural Engineering. It is a part of an undertaking of broader scope covering five southern states. It involves a survey of 94 plantations in the region, 66 of which used tractors and mules, and 28 used mules only.

While no general conclusions are drawn, a comparison of tractor and mule power for farm operations in the region shows the economy of tractors for those operations which utilized most of the available power, such as flat breaking and disking. On the other hand, the difference in cost of harrowing with a tractor and 10-ft harrow and with 2 mules and a 7 or 8-ft. harrow is in favor of the mules because the tractor was used at approximately half of its maximum efficiency. Also the cost per acre of harrowing with 3 mules was greater than that with 2 mules, probably because the 3-mule teams could have drawn a larger implement.

It also was found that the quality of work in bedding may vary widely even with middle bursters of the same size, since depth of bursting is an important factor.

The costs of cultivating per acre varied upward from the tractor to the 1-mule team. A comparison of trucks and mules for road hauling showed the ton-mile cost of road hauling with trucks to be much less than that with mules.

**Surface Water Supply of the Great Basin, 1930** (U. S. Geological Survey, Water-Supply Paper 705 [1931], pp. V + 92, fig. 1).—This report, prepared in cooperation with the states of Utah, Nevada, California, Oregon, and Wyoming, presents the results of measurements of flow made on streams in the Great Basin during the year ended September 30, 1930.

**Seepage and Drainage of Irrigated Land.** H. E. Murdock (Montana Station [Bozeman] Bulletin, 25 [1932], pp. 32, figs. 24).—This bulletin presents the results of investigations of the injurious results of seepage on irrigated lands and of ways and means of correction and control. It is pointed out that most of the drainage problems of Montana occur in those regions where there are underlying strata of porous material through which gravity water readily passes.

It was found that a lumber-box drain in water-soaked soil lasts well, and that where the soil is likely to be washed away from underneath the drain a closed bottom box is feasible. It also was found that surface water should not be allowed to run over the drain line, and that a sump that can be cleaned out should be used where necessary to admit surface water into the drain. Irrigation water should be carried over the drain line in a flume.

Much general information of a practical character is given on the planning and installation of drains in seeped and water-logged lands.

**Agricultural Engineering Investigations at the Alabama Station** (Alabama Station [Auburn] Report 1931, pp.11-13).—In experiments by E. G. Diseker with machinery for planting oats, of four different combinations of equipment used, a combination involving an end-gate seeder, 2-mule wagon, 8-ft wheat-land plow, and a 15-30 tractor was the most economical of fuel and labor, and the yield of oats was as good as with any of the other methods.

In weed control studies, Diseker found in tests of the rotary hoe for the cultivation of young corn and cotton that the implement could be used profitably on black belt and sandy soil. It also was found to be a desirable implement for the pre-cultivation of sandy soil, just before planting.

The use of a 1-horse spring tooth weeder to break crusts on cotton just coming up aided in getting up a stand of cotton and gave a light cultivation for the young crop in the row and middles.

In a continuation of the soil dynamics studies, M. L. Nichols accumulated evidence indicating that the film moisture on the colloidal particles of soils dominates and practically determines all of the physical reactions of the soil. Further studies of friction between soil and various plow metals resulted in the determination of a mathematical formula from which friction values may be determined from the colloidal content of non-plastic soils and from the Atterberg consistency constants of plastic soils. The abrasive power of soils was found to depend upon the sand content, other soil properties apparently exerting little or no effect. It also was found that the injurious puddling effect of pressure varies with the colloidal content of the soil and that a sliding motion of the surface applying force results in greater puddling injury than when the pressure is applied directly.

Laboratory studies of the draft of implements in various soils showed that draft is proportional to the depth at which the implement operates in the soil and depends upon the shear value of the soil. It also is proportional to the apparent specific gravity of the soil. The effect of the slope of the surface of tillage implements on draft was found to be governed by the general laws of the inclined plane.

The tentative conclusions drawn from soil erosion studies by Nichols and H. Sexton were that the relation of rainfall to run-off and amount of material eroded is governed by amount and rate of rainfall, moisture content of soil before rain, soil structure, surface protection, and surface shape. The results are taken to indicate that the critical velocity of rain water on Cecil clay soil is reached on grades between 10 and 15 per cent.

Tabular data are presented showing the relation of surface protection and structure of soil to erosion.

**Agricultural Engineering Investigations at the Washington Station** (Washington College Station [Pullman] Bulletin, 260 (1931), pp. 10, 11, 55-57, 70-73).—Experiments by H. L. Garver and J. Knott on the irradiation of cows' udders and flanks and of feeds with ultra-violet light showed no increase in milk flow or in butterfat from the use of either the carbon-arc or quartz-mercury lamp.

Experiments by Garver on orchard irrigation by overhead sprinklers showed that the costs of this system are generally higher than where the furrow system of irrigation is used, but that the sprinkling system appears to be of value for steep slopes or coarse soils.

Tillage and soil moisture studies, conducted by H. M. Wanser and H. D. Jacquot at the Adams Substation, showed that the water from a rapidly melting heavy snow blanket is more rapidly absorbed by a cultivated surface and that the moisture from winter conditions which produce a light run-off is absorbed better by uncultivated surfaces.

Experiments on terracing and on the operation of machinery on terraced land, conducted by P. C. McGrew at the Pacific Northwest Soil Erosion and Moisture Conservation Experiment Station in cooperation with the U.S.D.A. Bureau of Agricultural Engineering, showed that considerable difficulty was experienced in operating machinery over terraced land. This was particularly true of the peg-tooth harrow with rigid drawbar, and it was necessary to install a hinged drawbar. It was found

(Continued on page 222)

# AGRICULTURAL ENGINEERING

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## Engineers and Use of Machines

**"THE ENGINEER** has made machines available to all people; he cannot escape the responsibility of directing the people who acquire these machines in their intelligent use."

This sentence from Arthur Huntington's address published in this issue summarizes a representative trend in engineering thought.

There was a long period of history when the progress of the human race was limited by the capacity of its individual members to achieve specific material results; to produce the means and substance of life and commerce.

A profession developed and justified itself in helping people to meet those needs; to achieve specific material results. It applied the sciences of mathematics and physics to the solution of physical problems. It found the materials and forces of nature to be such that they could be combined and applied in machines, each of which would do better than human hands some one operation or small group of operations.

The crowning glory of the machine is its specialized efficiency and capacity. This characteristic has changed the world economics from one of family self-sufficiency to one of local, regional and international interdependence. It is obvious that no one individual or family can build or acquire and use enough different machines to meet its needs. Only the simplest devices lend themselves to increasing the satisfactions of self-sufficiency. But a large enough group, operating in coordination enough different machines, and exchanging the products of their operations on a fair basis, can provide for the needs of its individual members far more amply than could those same individuals working alone, each trying to do everything for himself. This is "group sufficiency," made possible and desirable by engineers and their developments. It has removed from the path of progress the difficulty of achieving specific material results.

The varying effectiveness with which this group sufficiency has been practiced—with which the mechanical capacity of the group has been applied to meeting the material needs of its individual members in various times, places, and circumstances—suggests not only its great possibilities, but the lack of a sure technique of coordination and control. With continued increase in the production and use of machines their coordination and direction,

to insure that the achievement of specific material results accomplishes the end of meeting human needs, becomes increasingly difficult and important.

Should not the same group of minds which develops machines also logically develop a technique for their effective direction and coordination in the achievement, not merely of material results, but of desirable human objectives? Failure of this leadership to arise from other sources lends strength to the idea that this is, in fact, their responsibility.

## Correcting Misunderstandings

**"MORE PILLS FOR FARMERS"** was the title of an editorial in the June 24 New York "Sun." With typical editorial vehemence it spluttered and fumed at agricultural engineers for demanding a chance, at the ASAE meeting in Columbus, "to try their pills and nostrums for the diseases of agriculture." Some other papers brewed similar misunderstanding.

Possibly the hurried editorial writers of city dailies are not entirely to blame for their misconception of the Society's purposes. Organizations, meetings, and addresses have too often been used to hide the motivation of a steam roller behind a camouflage of enlightenment, with agriculture a victim. The sophisticated, non-technical world has come to expect it. It could not conceive of a group which professes an interest in agriculture meeting, at a time like the present, simply to spread information; to help it own members, farmers, and others to get their bearings in the agricultural sea of problems and impending developments; to improve the direction, cooperation, and effectiveness of a technical work in the interest of humanity. It assumed that the Society approved and advocated the ideas brought out by individuals in this meeting. But the Society sponsored no new law; offered no plan of agricultural relief. Its failure to do so openly and aggressively was taken to reflect either inefficiency or strategy. Skeptics take it for granted that organizations have ulterior motives. If no plausible one is apparent they will credit the organization with having it cleverly hidden.

It is up to all truly scientific and technical societies and their individual members to let the non-technical public know that they have no ulterior motive; that the purpose of their discussions is not to force or urge the public to indulge in highly theoretical social or political experiments, but to bring to light truths for such use as the public may make of them.

Dr. E. A. White, for example, took the trouble to explain to the editor of the New York "Sun," in response to the editorial mentioned, his views on the relation of agricultural engineers to agriculture. The editor printed his letter, thereby spreading accurate knowledge of what agricultural engineers are really trying to do. Dr. White, expressing his viewpoint briefly for the consideration of agricultural engineers, says: "As I see it, it is not our job to run or even attempt to run agriculture. That should be left to the farmers. However, engineering developments have a most important bearing upon agriculture, and therefore it is the responsibility of the engineer to keep agriculture as fully informed as possible regarding what is going on."

## Applying Research Results

**THE SUGGESTION**, in the recent annual report of the director to the C.R.E.A., of a search for new and promising research developments applicable to farm productive enterprises, seems appropriate to all technical branches of agricultural engineering.

Research results may well be employed to the fullest possible extent in facilitating current economic readjustments—adaptation to engineering progress. It seems highly probable that a conscious, diligent review of new knowledge, of recent and preliminary research results, in all agricultural-engineering techniques, will suggest new farm applications with profit and efficiency possibilities worth developing.



# A.S.A.E. and Related Activities

## Progress, Proposed Program Reported at C R E A Meeting

THE Committee on the Relation of Electricity to Agriculture held its ninth annual meeting at Chicago, July 15.

Progress in rural electrification, the work of the Committee for the past year, and a suggested program for the Committee for the coming year were outlined in the ninth annual report of the director, Dr. E. A. White, to the Committee.

Summing up the situation Dr. White said, "We may well be proud of developments but must admit that these are much short of possibilities." He presented figures which supported his conclusion that "the value of electric service to agriculture promises to be so great as to carry developments forward under these most trying (general economic) conditions." These figures showed consistent increases over a period of years, including 1931, in the number of farms having electric service; increases, also including 1931, in the amount of power used; and the geographic distribution of farms served by electric light and power companies. They showed that in six states more than 50 per cent of the farms are served by central stations; in eight additional states the percentage of connected farms is above 25; of all the farms in the United States 11.1 per cent are now served by electric companies; in 1931 the number of farms served increased 7.5 per cent and the energy used, 5 per cent; for states in which irrigation plays little part in energy use, the increase last year was 9.3 per cent in farms served and 15.8 per cent in energy used.

Activities of the year cited in the director's report included publication of a revised edition of "Electricity on the Farm and in Rural Communities," preparation of a set of lessons to familiarize home economics workers with electricity and its possibilities sufficiently to enable them to advise on its use in homes, cooperation in the completion of a set of rural electrification exercises for use in vocational agriculture classes; a start on a survey of electrically operated farm equipment; and publication of a report on research in rural electrification (C.R.E.A. Bulletin Vol. VI, No. 1).

Faced with the necessity of making a reduced budget yield maximum returns Dr. White recommended that for the ensuing year the Committee "concentrate on: (1) Those activities which will keep the rural electrification movement in good working order, and (2) Those activities which, under present conditions, promise to assist

the farmer in securing a much needed financial return." The program outlined to attain those objectives included close contact with state and other rural electrification personnel; discontinuance of the C.R.E.A. News Letter and initiation of (1) a mimeographed bibliography service and (2) brief publications containing information on applications with money-making possibilities; a search for new and promising research developments applicable to farm productive enterprises; mimeographing and distribution of the home economics exercises previously referred to; and continuance, on a restricted scale, of the field survey of electrically operated farm equipment."

## Builders' Short Course Held at Louisiana State University

A TWO-DAY Builders' Short Course sponsored by the department of agricultural engineering, Louisiana State University, was held at that institution, June 23 and 24. About 150 home owners, future home owners, and contractors attended.

Addresses were short and to the point. Subjects covered included fire prevention, prevention of termite damage, building construction, home landscaping, home lighting, painting, design of the small home, lumber grades, insulation, plaster, heating, plumbing, roofing, built-in equipment, and other subjects of less direct interest to agricultural engineers.

Exhibits of building materials and household equipment were on display in the agricultural engineering department.

The department plans to make this short course an annual event.

## Personals of ASAE Members

J. Macgregor Smith, professor of agricultural engineering, University of Alberta (Can.), is senior author of Circular No. 14 of that institution, entitled "The Header-Barge Method of Harvesting." It was published to meet a popular demand for information on the barge system of harvesting.

## ASAE Meetings

North Atlantic Section — Albany, New York, October 27, 28 and 29.  
Power and Machinery Division — Chicago, Illinois, November 28 and 29.

## Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the July issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Guy T. M. Bevan, chief engineer, Massey-Harris Co., Ltd., Toronto, Ont., Canada.

Enrique Burgos, manager, "La Hormiga," San Clemente, Chile, South America.

Henry P. Fritsch, secretary-treasurer, Vane-Calvert Paint Co., St. Louis, Mo.

Grace L. Pennock, household appliance specialist and editor, Delineator Institute, 25 Prospect Place, New York City.

Gail M. Redfield, research assistant, Home Economics Department, Purdue University, Lafayette, Ind.

## New ASAE Members

John C. Keplinger, Hercules Motors Corporation, Canton, Ohio.

Lee W. Minium, Box 55, College Station, Brookings, So. Dak.

## EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

AGRICULTURAL ENGINEER, graduate of Virginia Polytechnic Institute in agricultural engineering, seven months training in rural electrification engineering by the Westinghouse Electric & Manufacturing Company, one and one-half years experience with large power company, and farming experience, desires new position with power company or electrical equipment concern. Would consider college or extension work. Age 25. Married. MA-221.

AGRICULTURAL ENGINEER, with bachelor's degree in agricultural engineering from Kansas State College, master's degree from University of Missouri, and with experience in research work in soil erosion control and farming experience, desires position in college or extension work. Would also consider other type work. Age 24. Married. MA-220.

that the chisel type implement, duck foot, and tandem disk can be used to advantage on terraced land.

**[Agricultural Engineering Investigations at the Mississippi Station],** T. N. Jones (Mississippi Station [A & M College] Report 1931, pp. 7-9).—Experiments in the mechanical features of hay curing indicated the value of a side delivery rake and hay loader in reducing the necessary man labor. A brief description of the set-up for power and tillage studies is included.

**Evaporation from Free Water Surfaces,** C. Rohwer (U. S. Department of Agriculture, Technical Bulletin 271 [1931], pp. 96, pls. 10, figs. 15).—The studies on which this report is based were conducted in cooperation with the Colorado Experiment Station. They deal with the factors causing evaporation, the derivation of the general law under which these factors operate, and the evaluation of the relation between evaporation as it takes place from various types of standard evaporation tanks and as it is found to occur from a large water surface.

The calibrations of the optical evaporimeter used in measuring evaporation under still air, under controlled conditions in the laboratory, and under fully exposed conditions outside showed that in general the average maximum deviation from the mean values of the constants was between 4 and 5 per cent. A comparison of vapor pressures determined by the sling and by aspiration psychrometers indicated that the sling psychrometer gave consistently lower results, the mean difference being 4.08 per cent. However, both of these psychrometers gave higher values than those determined by the Alluard dew point hygrometer.

For still-air conditions in the laboratory, there was no relation between the evaporation and the temperatures of air and water, but there was a definite relation between the difference in temperature and the evaporation, and between the difference in vapor pressure and the evaporation. Expansion and contraction due to temperature changes were found to have a definite effect on evaporation observations, but may be eliminated.

Tests on the effect on evaporation of expansion and contraction due to temperature changes showed that the evaporation from the oil film used to cover the water surface was about 2 per cent of the evaporation occurring from a water surface under similar conditions.

Under conditions of controlled wind in the laboratory, evaporation bore no relation to the temperature of the air or of the water, or to the difference in temperature of the air and the water. However, a definite relation was found to exist between evaporation and wind velocity and between evaporation and difference in vapor pressure. A definite increase in evaporation was observed with increase in altitude. A summary of data relating to the accuracy of methods of evaporation measurement also is included. A list of 34 references to the investigations of others bearing on the subject is included.

**Practical Ice Making,** A. J. Authenrieth and E. A. Brandt (Chicago: Nickerson & Collins Co., 1931, pp. 202, pls. 3, figs. 81).—This is a treatise on the equipment of ice plants and their operation. It contains chapters on physical principles, the raw material of ice manufacture, why water treatment is necessary in the manufacture of ice, air agitation in ice making, mechanical equipment of ice plants, operating with efficiency, care of freezing systems, the purity of manufactured ice, and low-temperature insulation.

**Builders' Materials,** R. F. B. Grundy (London and New York: Longmans, Green & Co., 1930, pp. X + 240, figs. 91).—This is a handbook of information relating to building materials. It contains chapters on timber—formation and uses; timber—classification; stone—formation and uses; stone—classification; stone—artificial and precast; bricks—manufacture; bricks—classification and uses; earthenware, stoneware, terra cotta, etc.; iron and steel—manufacture; iron and steel—uses; nonferrous metals; lime, gypsum, and plasters—manufacture; lime, gypsum, and plasters—uses, internal, and external; portland and other cements—manufacture; portland and other cements—testing; concrete—mass and reinforced; bitumen, asphalt (E), tar, etc.; glass; roofing materials; paint, varnish, distemper, etc.; and miscellaneous.

**The Advantages of Lessening Radiation in the Cylinders of Internal Combustion Engines,** F. I. Du Pont (American Philosophical Society [Philadelphia] Proceedings, 70 [1931], No. 4, pp. 345-352, figs. 2).—This report describes briefly experiments aimed at the elimination of detonation in internal combustion engines, drawing attention particularly to the development of tetraethyl lead for this purpose and to the technic involved. It was found that as little as 0.01 of 1 per cent will affect this phenomenon very appreciably and increase the thermodynamic efficiency to a very marked degree.

**Report of the Fourth Biennial Conference of the Western Irrigation and Drainage Research Association** (Tucson, Ariz., 1931, pp. [2] + 36).—The proceedings of the conference held at Tucson, Ariz., in July, 1931, are presented, including special papers on The Permanent Wiltting Percentage in Relation to Irrigation Experiments, by A. H. Hendrickson and F. J. Velh-meyer (pp. 3-7); Coordination of Research Concerning the Flow of Water in Soils, by O. W. Israelsen (pp. 7a13); Institutional Irrigation and Drainage Relationships, by W. A. Hutchins (pp.

17-20); Adjustments in Agricultural Research, by P. V. Cardon (pp. 22-25); Some Elements of the Economic Design of Wells and Pumping Plants, by M. R. Lewis (pp. 28-32); and Irrigation vs. Dry Farming Under the Ditch, by H. E. Murdock (pp. 33-35).

**A Practical Handbook of Water Supply,** F. Dixey (London: Thomas Murby & Co., 1931, pp. XXVIII + 571, figs. [140]).—This handbook deals with the improvement of the water supplies of European and native settlements in Africa. The geological aspects of water supply are described in some detail, particularly as regards the crystalline rocks. The practical aspect of retaining or recovering water is treated mainly from the point of view of settlers, missionaries, and others who are faced with the necessity of developing small water supplies although inexperienced in such work. Accordingly, methods of dam construction and of sinking wells and boreholes to moderate depths are described in detail. Information is given also on deepening and increasing the yield of wells. The technic of deep boring is described only in sufficient detail as to afford some insight into the nature of the work and its problems.

The various means of purifying water and of protecting water sources from contamination are fully described, and a chapter also is devoted to means employed for detecting underground water supplies.

The final chapter describes in brief outline the water supply conditions, as far as they are known at present, of the contiguous British dependencies of southern, central, and eastern Africa.

**A New Testing Process for Determining the Efficiencies of Cream Separators** [trans. title], W. Fritz (Die Technik in der Landwirtschaft [Berlin], 12 [1931], No. 11, pp. 284-286, figs. 8).—As the result of experiments with milk with varying cream lines, a new method for determining the efficiencies of cream separators is derived which eliminates the error, due to the variable cream lines of different milks, by expressing separating efficiency on the basis of the limiting diameter of the fat globules which will separate.

**Agricultural Structures in Belgium and the Belgian Congo,** E. Leplae (Les Constructions des Exploitations Agricoles en Belgique et au Congo Belge. Louvain: [Belgium] Libr. University, 1931, pp. [4] + 192, pls. 4, figs. 159).—This is an extensive description of farm buildings and structures and their arrangement as used in Belgium and in the Belgian Congo. Information also is given on the arrangement of farm home-steads. Numerous diagrammatic and other illustrations are included.

**Report of Committee on Engineering Experiment Stations, Association of Land-Grant Colleges and Universities, at Meeting of Engineering Section in Chicago, November, 1931,** C. A. Lory et al. (Association of Land-Grant Colleges and Universities, Engineering Experiment Station Record, 12 [1932], No. 1, pp. 6-8; also in Association of Land-Grant Colleges and Universities [Burlington, Vt.] Proceedings, 45 [1931], pp. 351-355).—The data presented show that in 1931 there was a total of 40 engineering experiment stations in the United States receiving legislative appropriations of \$108,450, college allotments of \$624,720, and financial support from other sources aggregating \$609,830. These stations employed a full time personnel of 184, a paid part time personnel of 283, and an unpaid part time personnel of 315. The financial support represented an increase over the previous year of nearly one-fourth of a million dollars, but the total personnel decreased 49.

**Lumber and Its Uses,** R. S. Kellogg (New York: Scientific Book Corporation, 1931, 4. ed., rev. and enl., pp. XIX + 378, figs. 101).—This is the fourth, revised and enlarged edition of the work previously noted.

## Book Review

**"International Directory of Agricultural Engineering Institutions"** is the English title of a bulletin listing for 47 countries in all parts of the world the important central agricultural engineering organizations and personnel; the university, college, and similar agricultural engineering departments and personnel; museums and exhibitions; and bibliographical notes. The information is published in the languages used by the various institutions furnishing the information. One index covers the institutions, subjects and personnel listed. It is supplemented by an index of names only of the individuals mentioned. Paper bound, VI + 178 pages, 6½x9 in. The International Institute of Agriculture, Villa Umberto 1, Rome 10, Italy. Price 15 lire (about 80 cents).

**"Irrigation in Western Washington"** is the title of a new bulletin published by the agricultural engineering department of the Puget Sound Power and Light Co. It covers methods and equipment for irrigation and information on the irrigation of specific crops. J. C. Scott, 5560 Stuart Building, Seattle, Washington, is agricultural engineer for the Company and will furnish the bulletin or additional information on request.